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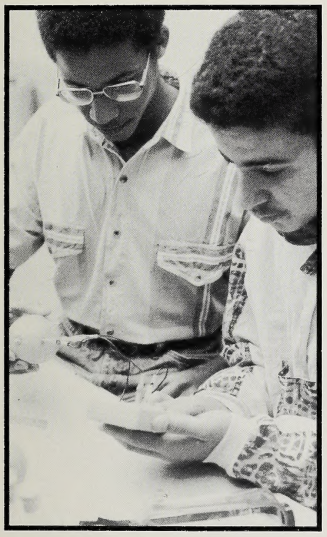

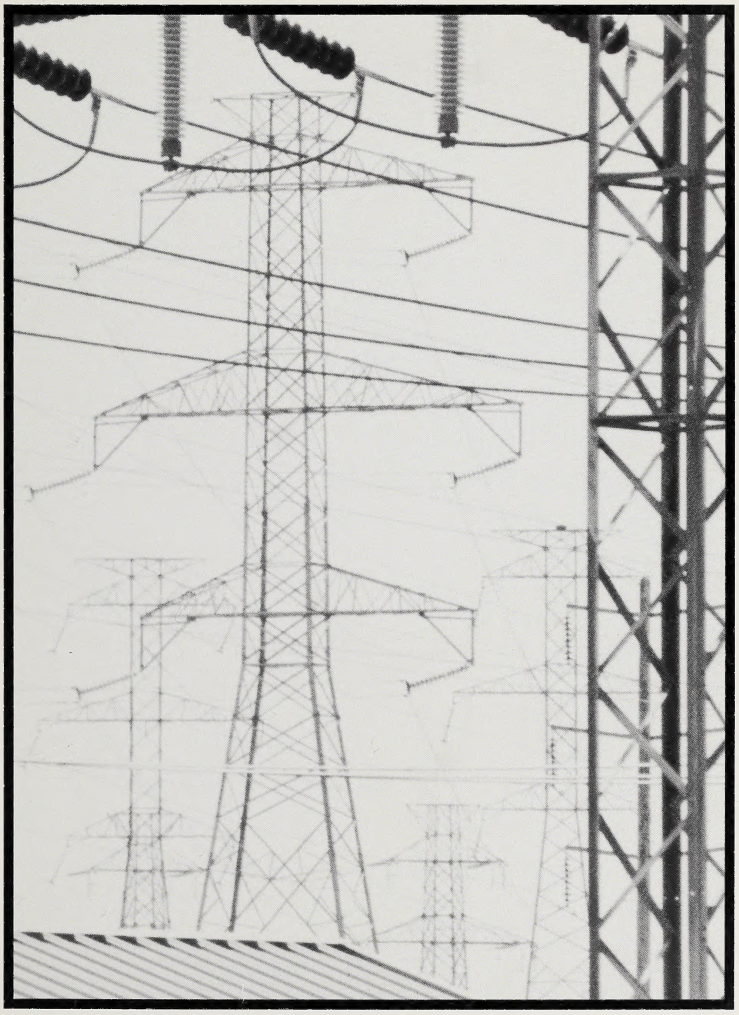

Module 4

Electromagnetic Systems

Distance Learning

Alberta EDUCATION

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Science 9

Module 4

ELECTROMAGNETIC SYSTEMS

Distance Learning

Alberta EDUCATION

Science 9
Student Module
Module 4
Electromagnetic Systems
Alberta Distance Learning Centre
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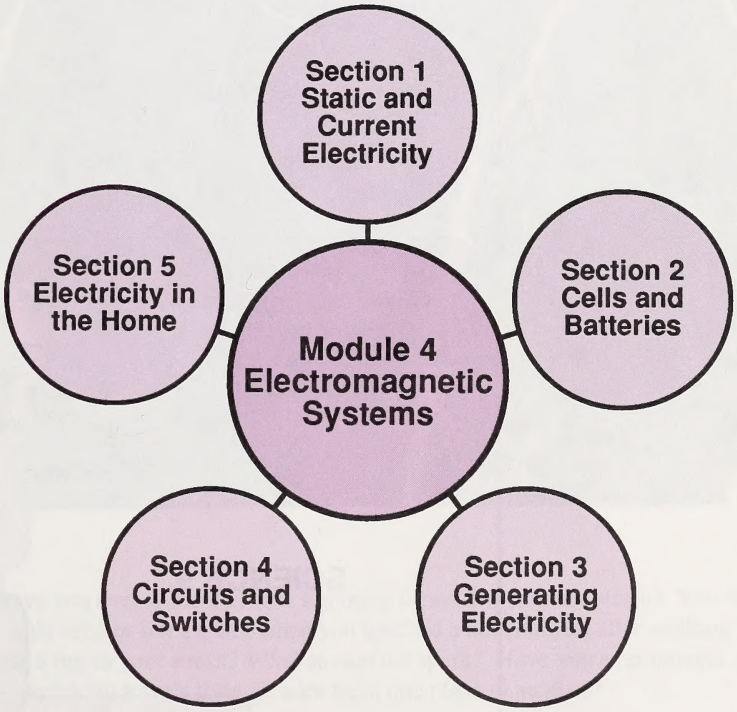
OVERVIEW

Imagine what it would be like to live without electricity. What would you do? There would be no television, radio, stove, or fridge. If you have ever experienced an electrical blackout, try to remember what it was like. What would it be like to live in that situation all the time? Most people tend to take electricity for granted.

In this module you will look at the principles of electricity. You will explore the basis for the production, control, and use of electrical energy. You will be asked to solve some practical problems using basic electrical circuitry.



Evaluation

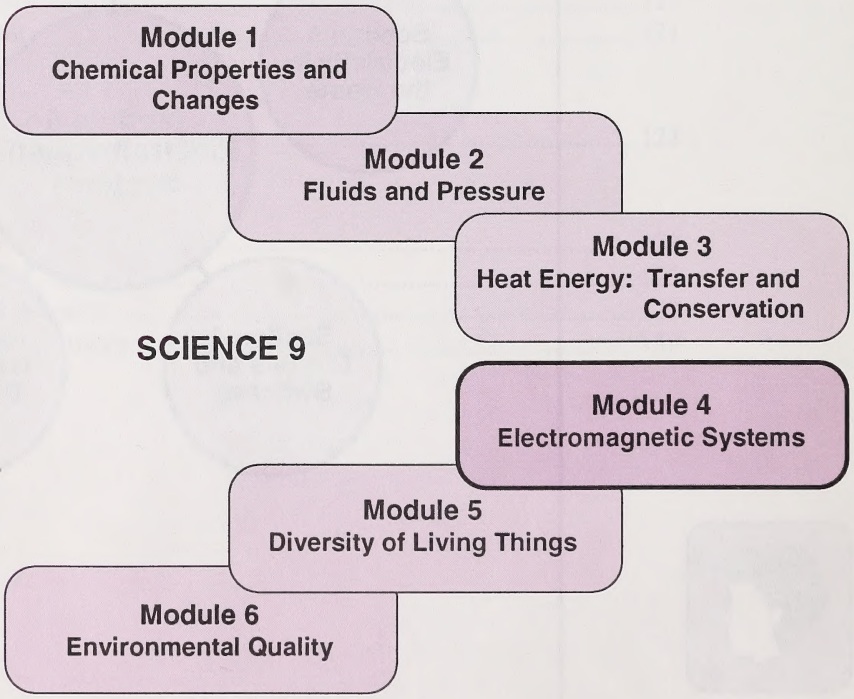
Your mark in this module will be determined by your work in the Assignment Booklet. You must complete all assignments. In this module you are expected to complete four section assignments and a final module assignment.

The assignment breakdown is as follows:

Section 2 Assignment	**15%**
Section 3 Assignment	**20%**
Section 4 Assignment	**25%**
Section 5 Assignment	**10%**
Final Module Assignment	**30%**
TOTAL	**100%**

Course Overview

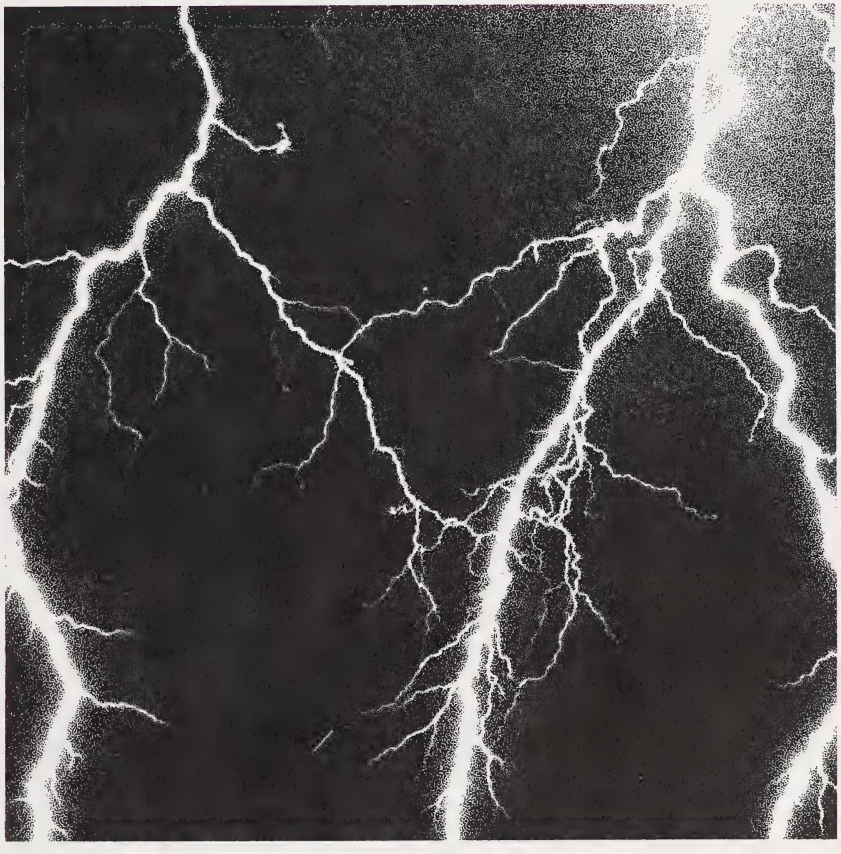
Science 9 contains six modules. The module you will be working on is highlighted.



Section

1

Static and Current Electricity



Have you ever wondered how lightning forms in a summer storm? You have probably seen or felt a spark when you touched a metal object after walking across a rug in your socks. What caused the spark? Have you ever thought about how electricity travels through wire from one place to another?

In this section you will discover the answers to these questions. You will also use a compass to construct a device to detect electrical current. You will learn that electricity can exert a force that can either push or pull. You will see how this force can move electricity from one place to another through certain materials.

Activity 1: Electric Forces and Static Electricity

At some point in time, you may have participated in some of the following activities:

- combing your hair and then picking up small pieces of paper with the comb
- rubbing a balloon on a sweater and then letting it stick to the wall
- rubbing a balloon on a friend's head and using it to make your friend's hair stand on end
- pulling clothes out of a dryer and seeing them stuck together by an invisible force

Read page 169 of your textbook.

1. Define the following terms.

   a. static electricity: _____

   _____

   b. electrical force: _____

   _____

Check your answers with your learning facilitator.

Investigation

Problem

Do **electric charges** have properties?

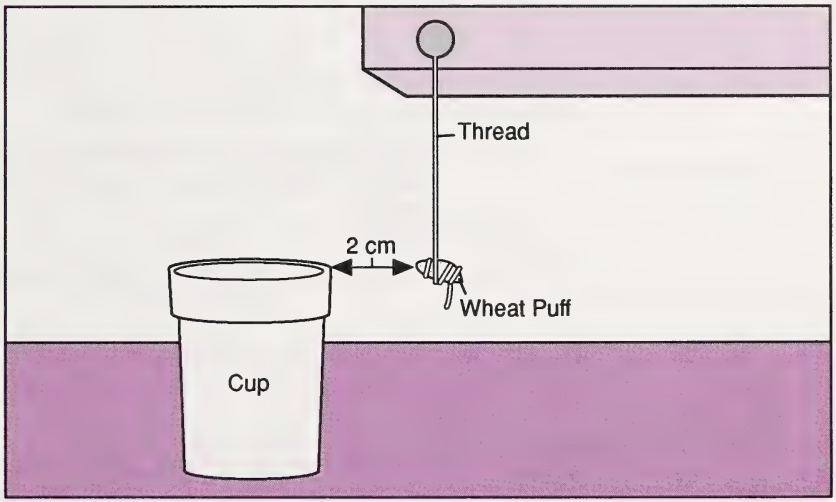
Electric charge: the positive or negative charge on an object or particle that exerts an electrical force

Materials

- one piece of puffed wheat or a similarly sized piece of polystyrene foam
- 20 cm of thread
- a strip of vinyl plastic (This can be cut from the lid of an ice cream pail.)
- a piece of wool or fur
- polystyrene foam cup

Procedure

- Use the thread and a cupboard door (or similar support) to suspend the piece of puffed wheat or foam chip. The piece of puffed wheat should hang at the same height as the top of the cup. Put the cup aside for use in the second investigation.



- Next rub both sides of the plastic strip vigorously with the wool or fur. This will create an electric charge on the strip and another on the wool. Bring the plastic strip close to the hanging piece of puffed wheat.

2. What do you observe when you bring the plastic strip (and an electric charge) close to the piece of puffed wheat?

_____

_____

- Allow the plastic strip to come onto contact with the bottom of the piece of puffed wheat. This will transfer some of the charge so that both the puffed wheat and the plastic strip have like charges.

- Bring the plastic strip close to the piece of puffed wheat a second time and observe what happens. Avoid touching the puffed wheat with your hand so that it will continue to have the same charge as the plastic strip.

3. How has the response of the puffed wheat changed?

4. What type of force occurs between like charges?

- Now rub the wool or fur against the plastic strip again. This time, however, bring the surface of the wool or fur close to the piece of puffed wheat.

5. How does the piece of puffed wheat respond to the charge on the wool?

6. How is this response different from the one observed in question 4?

7. Is the charge on the wool the same as the charge on the plastic strip? How do you know?

Note: If you are unsure about any of the answers for questions 2 to 7, remove the charge from the piece of puffed wheat by touching it with your finger and then repeat the procedure.

Analysis

8. What evidence is there for the existence of forces between electrical charges?

_____

_____

9. Use your observations to determine whether attracting or repelling forces would be observed between the following charges.

Type of Force

a. a charged object and an uncharged object _____

b. two like charges _____

c. two unlike charges _____

10. Why were you asked to touch the piece of puffed wheat at the end of the procedure?

_____

_____

Check your answers with your learning facilitator.

Read A Theory of Electricity on page 171 of your textbook.

11. Name the two electrical charges observed in your investigation.

_____

_____

12. What charged particle is responsible for the movement of negative charges?

_____

13. State the three laws of electrical charges.

Check your answers by turning to the Appendix, Section 1: Activity 1.

Investigation

Problem

How do electrical charges move?

Materials

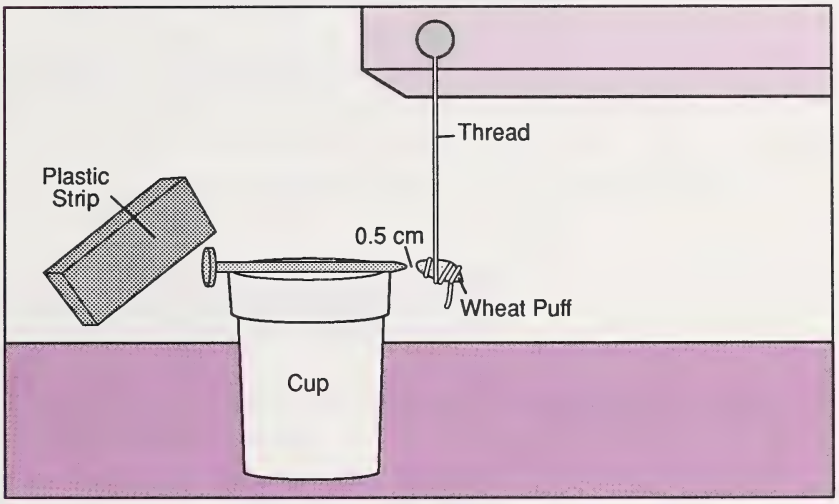
The following materials, in addition to the materials from the previous investigation, will be needed for this investigation.

- a polystyrene foam cup
- a 10 cm common nail
- a glass rod
- a 10 cm wooden dowel

Procedure

- Using the same setup as you used in the first investigation, place the cup in position so that the piece of puffed wheat or foam chip is even with the top of the cup.

- Now set up the nail and the cup as shown in the following diagram.



- Charge the plastic strip by rubbing it with wool or fur. Bring the plastic strip into contact with the end of the nail. Observe the response of the piece of puffed wheat.
- Remove the charge on the puffed wheat by touching it with your finger.
- Repeat this procedure using the glass rod and the wooden dowel in place of the nail. Observe the response of the puffed wheat for each test.

Analysis

From this investigation you should realize that an electrical charge is able to pass through certain materials, such as a nail, but is unable to go through other materials, such as glass rods or wooden dowels. Materials that allow electricity to pass through them are called **conductors**. Materials that do not allow electricity to pass through them are called **non-conductors** or **insulators**.

Conductor: any material that allows an electrical charge to travel through it

Non-conductor: any material that does not allow an electrical charge to travel through it

Insulator: a non-conductor

14. What observations tell you that an electrical charge can travel through some substances and not others?

15. Which substance(s) are conductors of electricity?

_____

16. Which substance(s) are non-conductors of electricity?

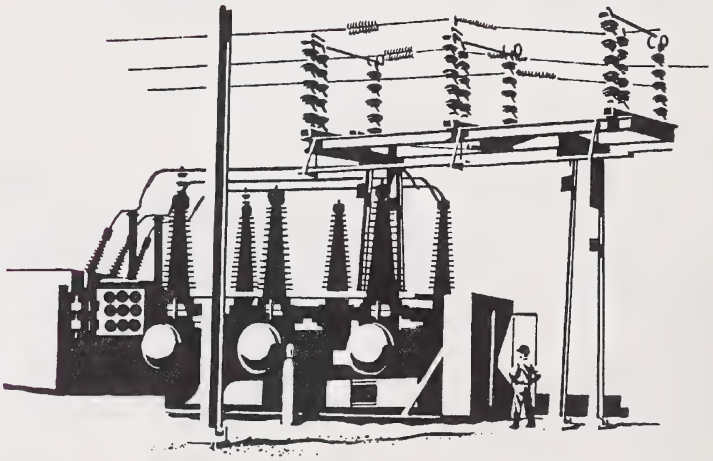
_____

_____

Check your answers by turning to the Appendix, Section 1: Activity 1.

Your observations in this investigation are now going to be used to develop an explanation of electricity.

Activity 2: Current Electricity



You have just seen that electricity produces a force that can either push or pull. You also found out that electricity can travel along a pathway. You will now expand these two ideas in order to understand some basic principals of electricity.

9 Science Directions

Read page 172 of your textbook.

1. What is meant when you talk about current electricity?

2. What two things do you need in order to make electricity move from one point to another?

3. Current electricity can be very dangerous. What is one thing you should never do around the house?

Check your answers by turning to the Appendix, Section 1: Activity 2.

You have probably received a shock from static electricity. You may even have received a shock from a wire carrying an electrical current. But many wires that carry electricity do not shock you. Besides, this is not a safe way to detect current electricity. How can you safely determine if a wire is carrying an electrical current?

Investigation

9 Science Directions

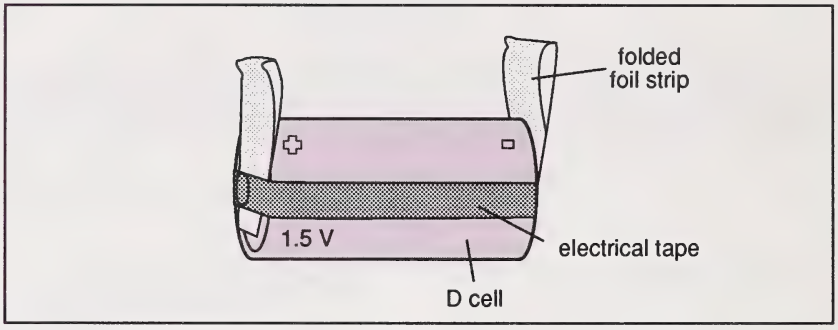
Refer to Activity 4-2 on pages 173 and 174 of your textbook.

4. What is the problem for this investigation?

Check your answer with your learning facilitator.

- Collect all of the materials required for this investigation.

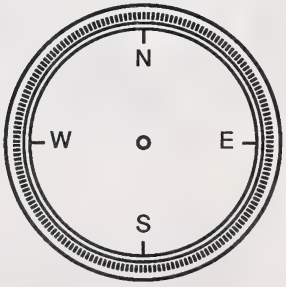
If you do not have the battery holder shown, you can make your own "power pack" using a 1.5 volt D cell, black electrical tape, and two 12 cm squares of aluminum foil. Fold the aluminum foil into two strips that measure about 1 cm × 6 cm. Tightly tape the aluminum foil to the ends of the battery with black electrical tape. These strips will act as terminals for attachment. Label the attachment terminals + and – to correspond to the terminals on the battery.



- Do steps 1 and 2 of the procedure.

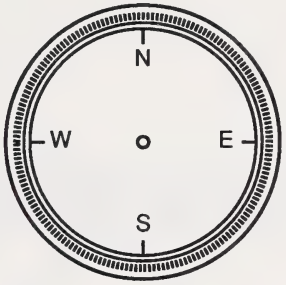
Caution: Use a brief connection only for steps 3 to 12 of this investigation. Be sure to disconnect one wire from the power source after each step. Wires become very hot when a "short circuit" is created by a wire between the poles of a battery. This is because there is nothing included in the circuit (such as a light) to offer a resistance to the flow of electricity. Damage to the battery can result.

5. Complete the following sketch by showing the position of the compass needle before connecting the cell in step 3.



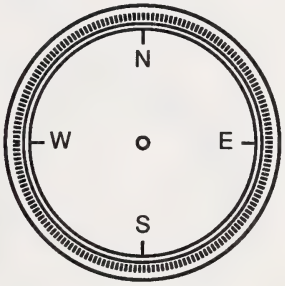
- Do step 3 of the procedure.

6. Complete the following sketch to show the position of the compass needle after briefly connecting wires to the cell.



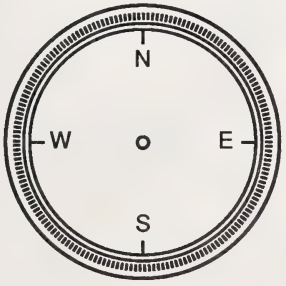
- Do step 5 of the procedure.

7. After reversing the connection, complete the following sketch to show the new position of the compass needle.



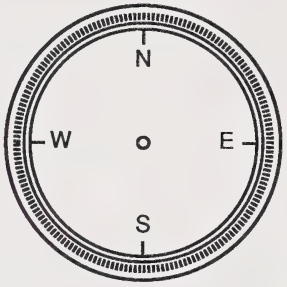
- Do step 6 of the procedure.

8. Indicate the position of the needle when the wire is below the compass and briefly connected to the cell.



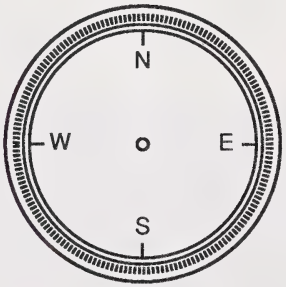
- Repeat step 6 of the procedure with the connection reversed.

9. Indicate the position of the needle after reversing the connection.



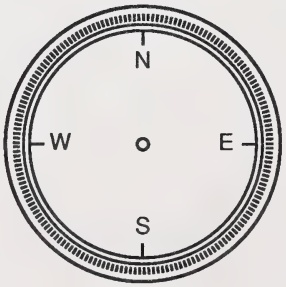
- Do steps 7 and 8 of the procedure.

10. Indicate the position of the needle when the wire is wrapped only once around the compass and the wire briefly connected to the cell.



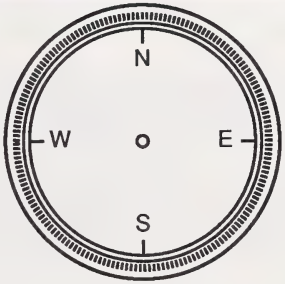
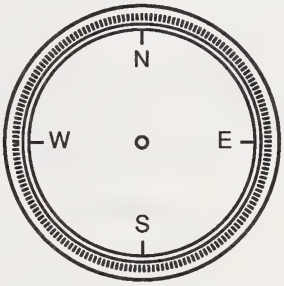
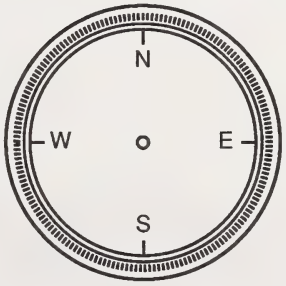
- Do step 10 of the procedure.

11. What is the position of the compass needle with the connection reversed?



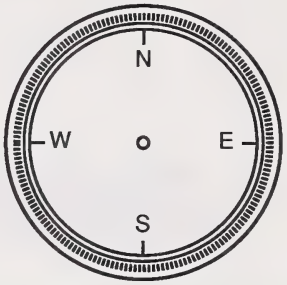
- Do step 11 of the procedure.

12. Using the following data table, sketch and note the positions of the compass needle as wraps of wire are added.

Number of Wraps	Compass Deflection (sketch position)	Notes
2		
5		
10		

- Do step 12 of the procedure.

13. Sketch the position of the compass needle when a light is included in the circuit.



Discuss your answers with your learning facilitator.

14. Do question 1 of Analysis on page 174.

15. Do question 2. (a) of Analysis.

16. Do question 2. (b) of Analysis.

17. Do question 3 of Further Analysis.

18. Do question 4 of Further Analysis.

Check your answers by turning to the Appendix, Section 1: Activity 2.

In your investigation you used a compass to detect current.

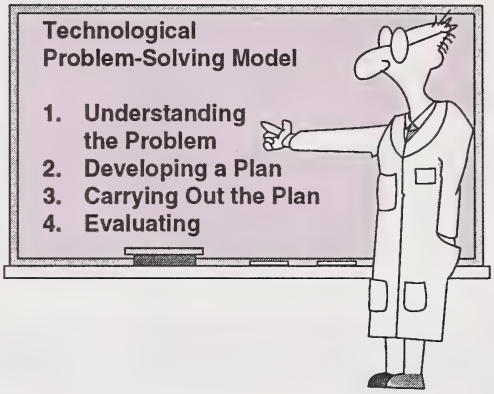
Read page 175 of your textbook to learn about commercial current-measuring devices.

19. What is an ampere?

Check your answer by turning to the Appendix, Section 1: Activity 2.

9 Science Directions

In the previous investigation you made a device to solve the problem of detecting current. Whenever you are solving a practical problem, you should apply the technological problem-solving model.



When you made the galvanometer, the textbook helped by telling you the problem and giving you a plan or procedure to follow. The observations that you were asked to make helped you to evaluate the design of the galvanometer. Without this kind of guidance, it is especially important to think about the technological problem-solving model as you solve practical problems.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Investigation

One of the main ideas that you need to understand about electricity is that it produces a pushing or pulling force that you are able to use to do work. Try the following investigation to see evidence of this type of force.

Problem

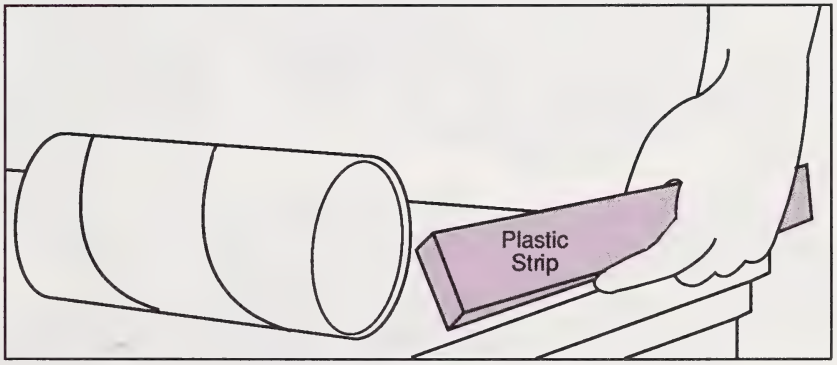
What is the nature of an electrical force?

Materials

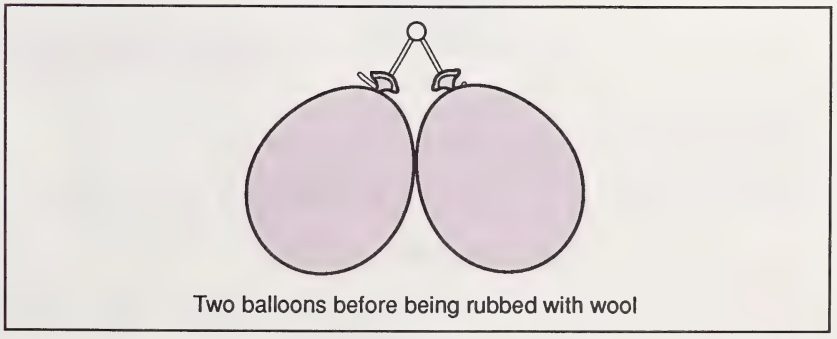
- plastic strip, comb, or ruler
- plastic wrap or wool
- small piece of paper (6 cm × 15 cm) and tape
- two balloons
- thread

Procedure

- Use the paper and tape to make a small tube that can roll across the table top. Rub both sides of the plastic strip vigorously with the plastic wrap or wool. Bring the plastic strip close to the paper roll until the roll starts moving. Slowly move the plastic strip away while trying to pull the paper roll along.



- Blow up two balloons and attach them each to 20 cm of thread. Suspend the two balloons from the edge of a table so that they are both touching each other. Rub each balloon with a wool sweater. Now let them hang back together and observe what happens.



Two balloons before being rubbed with wool

Analysis

1. What caused the paper roll to be pulled across the table by the plastic strip?

_____

_____

2. a. What happened to the two balloons?

_____

_____

b. Can you explain this?

_____

_____

3. Can static electricity exert a force? Explain your answer.

_____

_____

Check your answers by turning to the Appendix, Section 1: Extra Help.

Enrichment

Do either Part A, Part B, or both.

Part A

Investigation

Problem

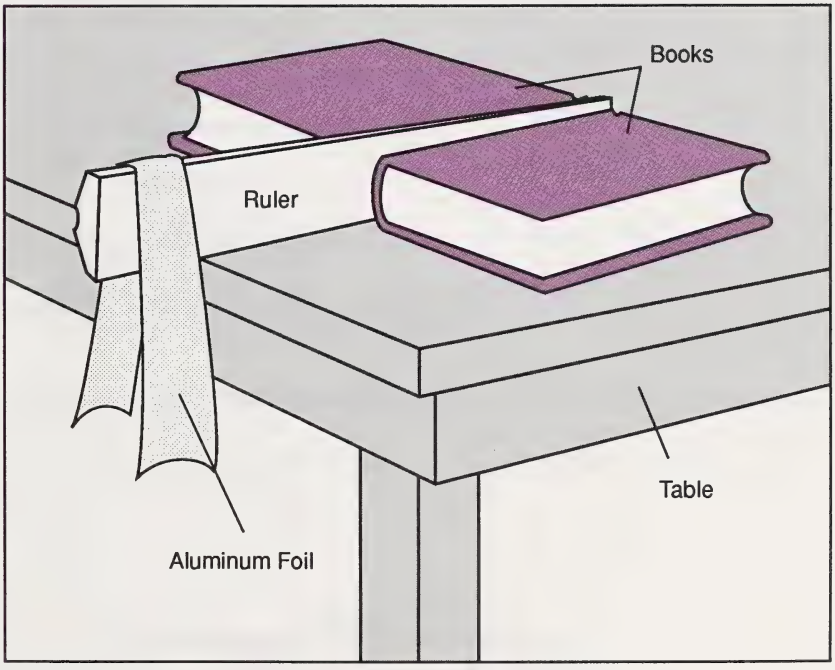
What is an electroscope and how can an electroscope be used to tell the type of charge on an object?

Materials

- aluminum foil
- plastic wrap or wool
- plastic strip, comb, or ruler
- glass rod
- silk or cotton cloth
- several hard-cover books

Procedure

- Gather the materials required for this investigation.
- Construct a simple electroscope as illustrated.



- Cut a strip of aluminum foil 2 cm wide by 20 cm long. Fold the strip of aluminum foil over the end of the ruler. Make sure that the foil ends are not touching each other. Rub the plastic strip vigorously with the plastic wrap or wool. Bring the plastic strip close to the top of the aluminum foil and then slowly pull it away.

1. What did you observe happening to the foil?

_____

_____

_____

- This time rub the plastic strip with the plastic wrap or wool and then touch the top of the foil.

2. What did you observe?

_____

_____

_____

3. If the plastic strip has a negative charge, the aluminum will now have a _____ charge.

- Now rub the glass rod with the silk or cotton cloth.
- Bring the glass rod close to the top of the aluminum strip and then slowly pull it away.

4. What did you observe happening to the foil?

_____

_____

_____

Remember the laws of electric charges.

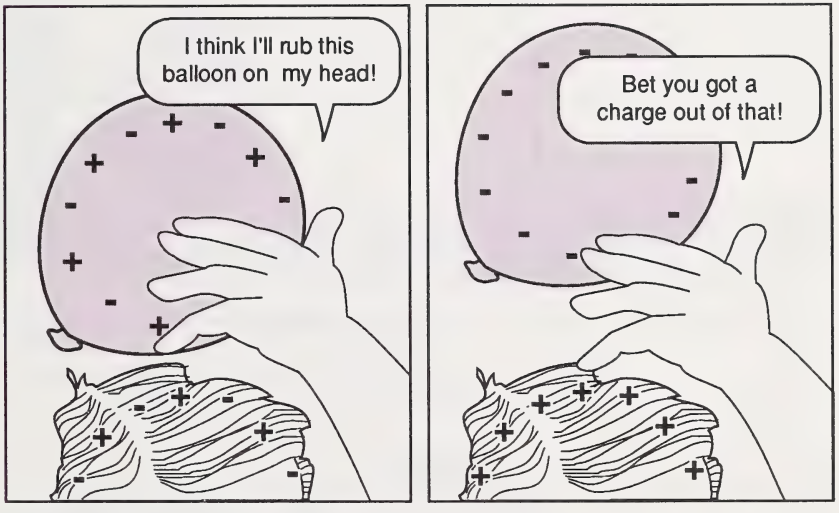
5. The glass rod has a _____ charge.

End of Part A

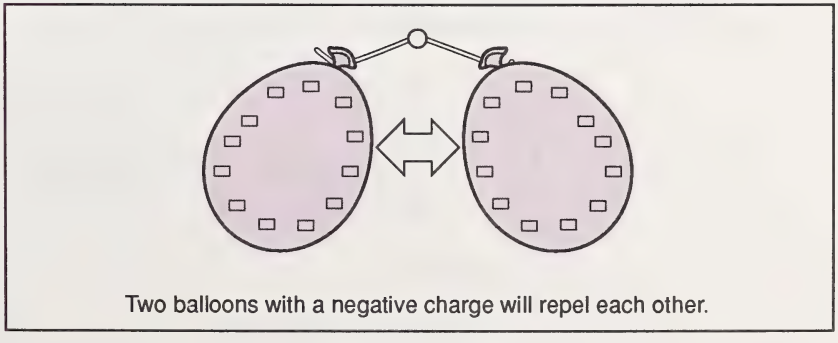
Discuss your answers with your learning facilitator.

Part B

All neutral or uncharged objects have a balance of positive and negative charges. By rubbing one material against a different material, you will cause some of its negative charges, or electrons, to be lost to the second material. When this happens, the second material has an excess of electrons, which means it has a negative charge.

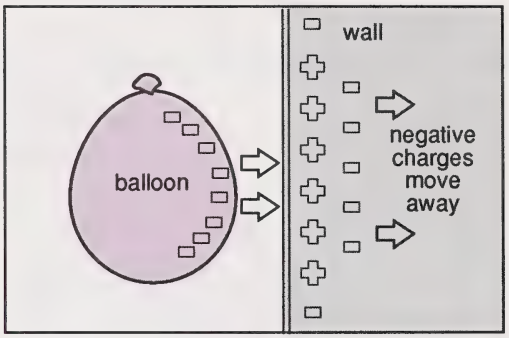


Almost any material can be charged, but some materials are easier to charge than others. Once an object has a charge, it can be attracted to a material that has a neutral or opposite charge. At the same time, objects of the same charge will push each other away, or repel each other.



Two balloons with a negative charge will repel each other.

In this example, when you rub a balloon against your hair or sweater, the balloon collects an excess of electrons, or a negative charge. If you then place this balloon against a wall, the negative charge in the balloon repels the negative charges in the wall. This means the surface of the wall now has a positive charge. The charges are opposite, therefore the balloon will stick to the wall.



Investigation

You can do this investigation on your own or in a small group where you can discuss the questions with each other.

Problem

How can you separate salt and pepper using electrical charges?

Materials

- salt and pepper shakers
- plastic strip
- wool or plastic wrap

Procedure

- Collect the materials required for this investigation.
- Place some salt and pepper together on a table top. Charge the plastic strip with plastic wrap or wool. Bring the plastic strip close to the pile and observe what happens.

Analysis

6. What did you observe?

7. Explain why this occurred.

_____

_____

8. Where might industry use electrical forces in a similar manner?

_____

_____

_____

End of Part B

Discuss your answers with your learning facilitator.

Conclusion

In this section you discovered that electricity can exert a force, either a push or a pull. These forces are able to move electrical charges from one place to another. You saw that certain materials are able to conduct charges from one point to the next, but other materials cannot. You called these materials conductors and non-conductors. You also built a homemade compass galvanometer to measure the flow of electricity. Through the use of this galvanometer, you should now realize that electricity can produce a magnetic field around a conductor.

Note: There is no assignment for Section 1. The activities of Section 1 are an introduction to what you will study in the remaining sections of this module. Proceed to Section 2.

Section

2

Cells and Batteries

DAVE MORRIS

What do all of these objects have in common? If you said that they are all used to supply electrical power, you were right! Have you ever wondered how a **battery** makes electricity?

In this section you will look at one of the most common sources of electricity, the **electrical cell**, or battery. You will understand why your portable radio or tape recorder stops working and you need to buy new batteries. You will be given a chance to build an electrical cell from a lemon and discover some other materials that can also be used for this purpose. You will start to see how you can use technology to control electricity.

Battery: two or more electrical cells operating as a single source of electricity

Electrical cell: converts chemical energy to electrical energy by creating a flow of electrons from a positive electrode to a negative electrode

Activity 1: An Electric Lemon

In this activity you will discover that a lemon can produce electricity.

Investigation

Refer to Activity 4-3 on page 177 in your textbook.

1. What is the problem for this investigation?

_____

_____

_____

_____

- Collect the materials required for this investigation. You may use an **ammeter** or a **multimeter** in place of the galvanometer.

Ammeter: a device that is used to measure current strength

Multimeter: a device that can be used to measure voltage, current strength, and resistance using different settings on the same instrument

Caution: If you are using a multimeter, read Measuring Direct Current Strength (Amperage) under Measuring Electricity in the Appendix at the back of this booklet for operating instructions. If you are using a different instrument, consult the operations manual for the particular instrument that you are using. You must follow the rules for safe operation to prevent damage to these instruments.

- Follow steps 1, 2, and 3 of the procedure.

2. Record the number of divisions through which the needle moves on the galvanometer or the digital reading of the multimeter.

_____

_____

_____

_____

- Do step 4 of the procedure.

3. Use the following data table to record the number of divisions through which the needle moves on the galvanometer or the digital reading of the multimeter.

Data: Comparing the Ability of Different Materials to Produce Current Electricity		
Substitution	**Instrument Reading**	**Comments**
copper wire for paper clip		
paper clip for copper wire		
_____ for lemon		
_____ for lemon		
_____ for lemon		
tap water in a cup for lemon		

4. Complete question 1 of Analysis on page 177 of your textbook.

Textbook question 1. (a):

_____

_____

_____

Textbook question 1. (b):

_____

_____

_____

5. Do question 2 from Further Analysis.

6. Do question 4 of Extension.

   Draw the connections between the two lemons and the galvanometer or multimeter in the following space. Show the instrument reading in the diagram and label all parts of the circuit.

Check your answers with your learning facilitator.

Activity 2: Voltage of Cells and Batteries

You have just seen how a lemon can produce an electrical current. How does a real battery work? You are going to find out in this activity.

9
Science Directions

Read page 178 of your textbook.

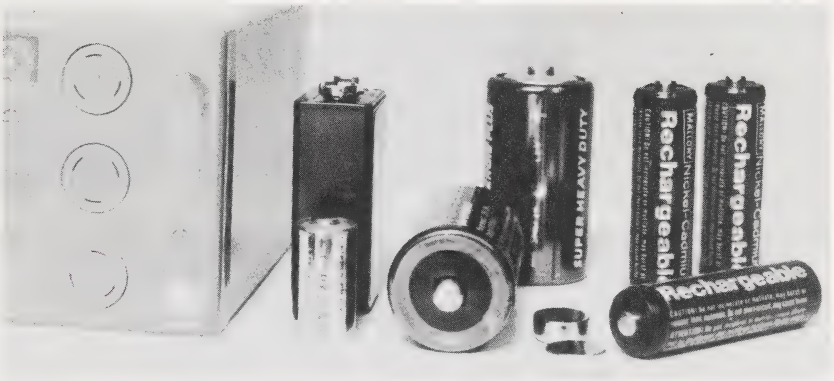


PHOTO SEARCH LTD.

1. How does an electrical cell produce an electrical current?

_____

_____

2. In the previous investigation you connected two lemons together. This is the same as connecting two _____ to make a _____.

Check your answers by turning to the Appendix, Section 2: Activity 2.

Volt: a unit used to indicate the force caused by a difference in electrical charge that is capable of producing an electrical current

Ampere: a unit used to indicate the strength of an electrical current

You can compare the flow of electricity in a wire to the flow of water in a garden hose. The "pressure" in the wire is measured in **volts**. Voltage would compare to the pressure that causes the flow of water from the nozzle of the hose. A hose with greater pressure in it would produce a greater flow of water.

In a similar manner, a battery with a higher voltage could supply more electric current. The amount of water flowing through the hose is the equivalent to the electric current. The amount of electrical current delivered is measured in **amperes**.

3. If your radio takes four D-size 1.5 V cells, the total voltage of the batteries within the radio is _____.

4. What device is used to measure the voltage of a battery?

_____

_____

Check your answers by turning to the Appendix, Section 2: Activity 2.

5. Write a short paragraph that explains how to connect a voltmeter or a multimeter to a power source.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

6. What symbols are used on the galvanometer to show the positive terminal and the negative terminal?

positive terminal: _____

negative terminal: _____

Check your answers with your learning facilitator.

Investigation

In this investigation you will decide which liquid would be best for making an electrical cell.

Refer to Part A of Activity 4-4 on page 179 in your textbook.

Do either Part A or Part B.

Do Part A if you have the materials listed in your textbook. Do Part B if you cannot obtain these materials.

Caution: If you are using a multimeter, read Measuring Direct Current Voltage under Measuring Electricity in the Appendix at the back of this booklet for operating instructions. If you are using a different instrument, consult the operations manual for the particular instrument that you are using. You must follow the rules for safe operation to prevent damage to these instruments.

Part A

- Collect the materials required for this investigation. You may use a multimeter in place of a voltmeter.

Caution: Use only the following liquids:

- tap water
- salt solution
- sugar solution
- vinegar
- soap solution

- Complete steps 1 and 2 of the procedure.

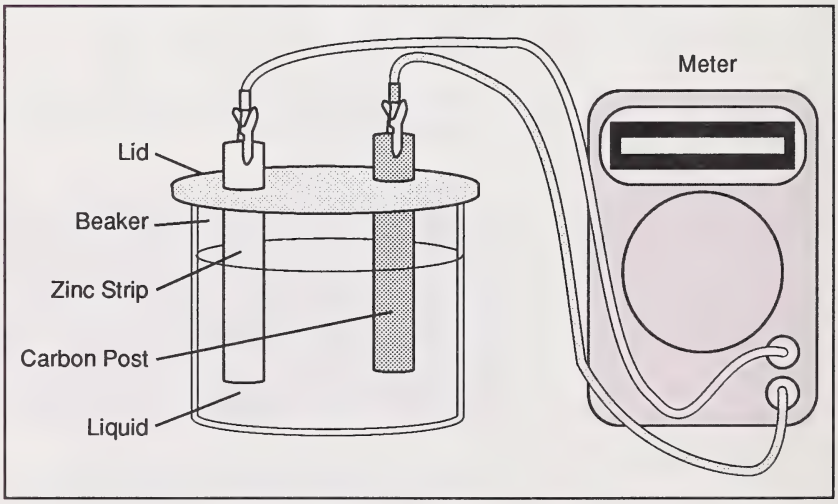
End of Part A

Part B

- Collect the following materials:
  - voltmeter or multimeter
  - two connecting wires (with alligator clips)
  - zinc strip
  - carbon rod
  - 250 mL beaker or glass jar
  - a plastic lid from a food container (the same diameter as the beaker or slightly larger)
  - 200 mL of each of the following liquids:
    - tap water
    - salt solution
    - sugar solution
    - vinegar
    - soap solution

- Cut holes in the plastic lid to hold the zinc strip and the carbon rod against the side of the beaker. These metal strips are now called the **electrodes.**

Electrode: the part of a battery that allows electrons to enter or leave



- Continue with step 2 of the procedure.

End of Part B

7. What is the problem for this investigation?

_____

_____

_____

- Do steps 3 to 8 of the procedure.

8. Use the following data table to record the voltmeter reading for each of the liquids used.

Data Table: Different Types of Liquid Versus the Voltage Produced

Liquid Used	Voltmeter Reading	Comments
Tap Water		
Salt Solution		
Sugar Solution		
Vinegar		
Soap Solution		

9. Which liquid gave the highest reading on the voltmeter?

_____

_____

_____

10. To ensure that the test was fair, what conditions did you have to keep constant?

Check your answers with your learning facilitator.

You have just discovered that liquids can affect the voltage in a cell. Do you think there are other factors that can also affect voltage?

Investigation

In this investigation you will look at different metals that can be used for making an electrical cell.

Refer to Part B of Activity 4-4 on page 180 in your textbook.

- Collect the materials required for this investigation, including one strip or rod of each of the following metals.

  – iron
  – aluminum
  – copper
  – zinc
  – carbon

11. What is the problem for this investigation?

- Do steps 1 to 3 of the procedure.

12. Use the following data table to record the voltmeter reading for each combination of metals used.

Data: Voltage Produced by Different Electrodes		
Metal Combination	**Voltage Reading**	**Comments**
carbon/zinc		
carbon/copper		
carbon/aluminum		
carbon/iron		
zinc/copper		
zinc/aluminum		
zinc/iron		
copper/aluminum		
copper/iron		
aluminum/iron		
copper/copper		

13. Which pair of metals gave the highest voltmeter reading?

14. To ensure that the test was fair, what conditions had to be kept constant in this investigation?

15. Complete question 3 of Further Analysis on page 180 of your textbook.

16. Now try to connect two of these cells together to get the highest voltage output. Draw the connection and show the galvanometer reading.

17. When you connect two or more cells together, you create a

_____.

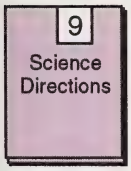
- Examine the photograph of the car battery shown in the introduction to Section 2.

18. How many cells does the car battery contain?

_____

_____

Check your answers with your learning facilitator.



Activity 3: Types of Cells and Batteries

Now that you have seen how a battery works, you are now going to take a short look at some of the different types of batteries.

Read page 181 of your textbook.

1. What are the two common features found in all cells?

_____

_____

_____

2. What are electrodes?

_____

_____

3. What is an electrolyte?

_____

_____

Caution: You should never cut open a battery to see what is inside. The electrolytes can be very dangerous.

4. Draw a simple diagram of a zinc carbon cell in the following space. Explain how the cell works. If you do not like to draw, then write an explanation that clearly explains how an electrical current is produced. You may do both if you wish.

5. What makes the rechargeable battery different from the zinc carbon cell?

6. What design features would be needed in a battery for each of the following situations?

   a. spacecraft:

   b. heart pacemaker:

   c. car powered only by batteries:

Check your answers by turning to the Appendix, Section 2: Activity 3.

Activity 4: Electron Flow in a Simple Pathway

You have seen how a battery produces electricity. You will now see how a flashlight works while being powered by electrical cells.

Investigation

Refer to Part A of Activity 4-5 on page 183 in your textbook.

1. What is the problem for this investigation?

_____

_____

- Collect all the materials that are necessay for this investigation. Besides those materials listed, you will need an ammeter or multimeter that can be used to measure current.
- How do you think the current varies with the brightness of the bulb?

2. In your own words, make a prediction as to how current and bulb brightness are related.

_____

_____

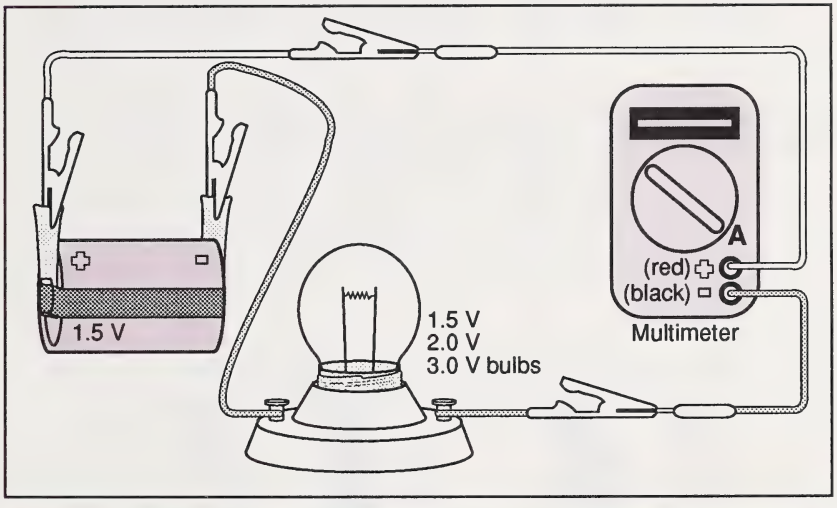
- Do steps 1 and 2 of the procedure.

3. Use the following data table to record the relative brightness of the bulbs.

Bulb Type	Brightness	Instrument Reading
1.5 V		
2 V		
3 V		

Share your answer with your learning facilitator.

- Next test your prediction by placing an ammeter (or multimeter) in the circuit as shown. However, do not make the final attachment to the cell until you check with your learning facilitator.



Caution: If you are using a multimeter read Measuring Direct Current Strength (Amperage) in the Appendix at the back of this booklet for operating instructions. If you are using a different instrument, consult the operations manual for the particular instrument that you are using. You must follow the rules for safe operation to prevent damage to these instruments. Do not proceed with measurements without the approval of your learning facilitator.

- Once you have received approval from your learning facilitator, proceed to measure the current with each of the bulbs.

4. Use the table in question 2 to record the current measured.

5. What is the relationship between the bulb brightness and current? Was this as you predicted?

- Do step 3 of the procedure.

6. Draw the arrangement that you used for step 3 of the procedure.

Check your answers with your learning facilitator.

Now that you have made a simple flashlight, you will discover a way to change the brightness without changing the bulb or the power source.

Investigation

Refer to Part B of Activity 4-5 on page 183 in your textbook.

7. What is the problem for this investigation?

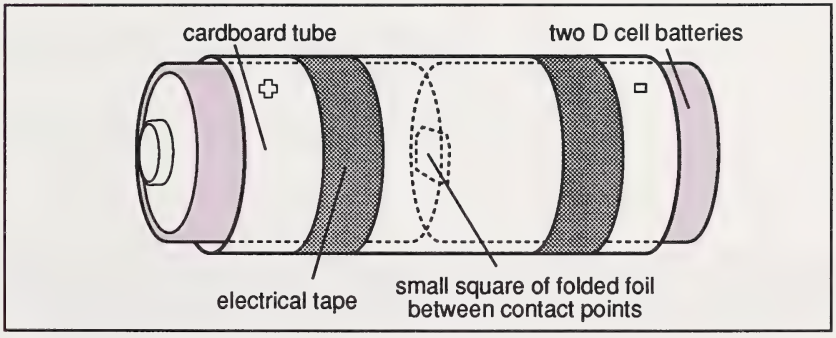
_____

_____

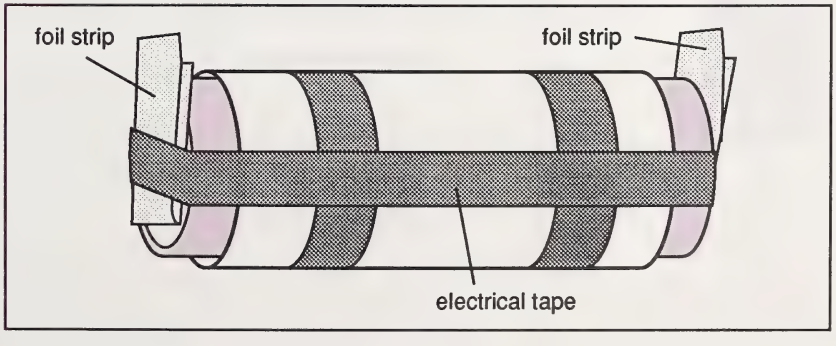
Caution: The nichrome wire may become too hot to touch while it is connected to the battery.

- Collect all the materials for this investigation. You will also need 50 cm of bare copper wire.

- If you do not have the battery holder shown, you can make your own "power pack" using two 1.5 volt D-sized cells, a cardboard paper towel tube, electrical tape, and two 12 cm squares of aluminum foil. Cut the cardboard tube lengthwise and use black electrical tape to wrap it tightly around two batteries lined up in series (+ and – terminals together). A small folded square of aluminum foil between the batteries will help to make a more definite contact.



- Fold the aluminum foil squares into two strips that measure about 1 cm ¥ 6 cm. Tightly tape these strips to the ends of the battery pack with black electrical tape. The strips of foil will act as terminals for attachment. The tape will also hold the battery pack together and keep the batteries in contact with each other. Label the attachment terminals + and – to correspond to the end terminals of the batteries.



- Do steps 1 and 2 of the procedure.

8. Record what happens to the brightness of the bulb.

_____

_____

9. Place your hand close to the nichrome wire. What do you notice?

_____

_____

_____

- Repeat steps 1 and 2 of the procedure. This time substitute copper wire in place of the nichrome wire.

10. What happened to the brightness of the bulb when a copper wire was used?

_____

_____

_____

11. As electricity flowed through the light and the nichrome wire, what two forms of energy could you observe?

_____

_____

12. Do question 1 of Analysis on page 183 of your textbook.

Textbook question 1. (a):

_____

_____

Textbook question 1. (b):

_____

_____

13. Do question 2 of Further Analysis.

14. Do question 3 of Further Analysis.

15. Do question 4 of Further Analysis.

Check your answers by turning to the Appendix, Section 2: Activity 4.

Resistance: a measure of how much a material resists the flow of electricity
The unit is the ohm (Ω).

You have seen how you can vary the brightness of a light bulb. This involved a very important characteristic of electrical conductors called **resistance**.

Read page 184 in your textbook to find out more about controlling electricity.

16. What is a resistor?

17. Use the idea of resistance to briefly explain how one of the following items works.

    - light bulb
    - electric kettle
    - oven
    - toaster

In this last investigation you moved the clip along the nichrome wire and were able to vary the brightness of the light bulb. This shows the simple principle of a variable resistor, or **rheostat**. This would be similar to a kink in the garden hose that reduces the amount of water flowing out.

Rheostat: a device that has a controlled variable resistance to the flow of electrical charge

18. In what devices would you find a variable resistor, or rheostat? At the same time try to explain what they do.

Check your answers by turning to the Appendix, Section 2: Activity 4.

Follow-up Activities

If you had difficulties understanding the concepts in the activities it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Do either Part A or Part B, or both.

If you want more practice constructing a battery and have the materials required, do Part A. If you would like to understand resistance better, do Part B.

Part A

In this section you constructed an electrical cell called a wet cell. This is the type of cell that you would find in a car. The car battery is a series of wet cells hooked together. However, the batteries that you would use in your tape recorder or radio are called dry cells. In this investigation you will construct a dry cell.

Investigation

Problem

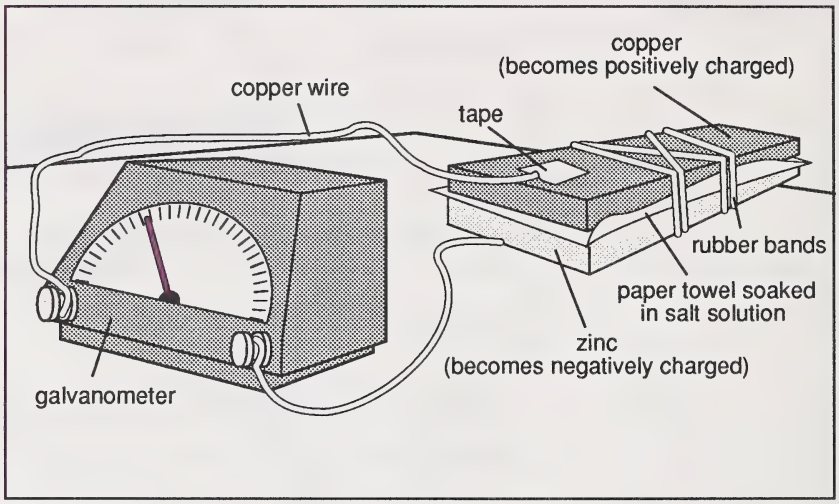
How is a dry cell made?

Materials

- galvanometer, ammeter, or multimeter
- connecting wires without clips
- tape
- rubber band
- paper towel
- salt solution
- two zinc metal strips
- two copper metal strips

Procedure

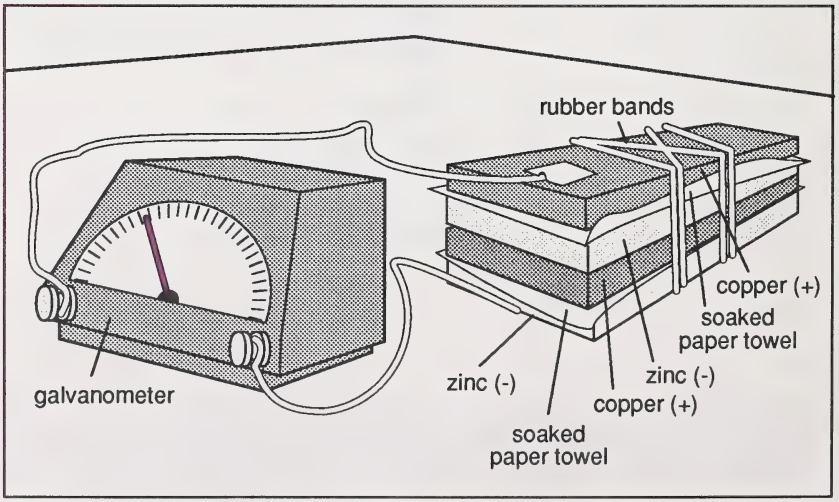
- Make a "sandwich" using your materials as shown in the following diagram.



1. What is the amount of deflection of the needle on the galvanometer or the reading on the ammeter?

_____

- Now make a "double sandwich" as shown in the following diagram.



2. What is the amount of deflection of the needle on the galvanometer or the reading on the ammeter?

_____

_____

3. How does your answer in question 1 compare with the answer in question 2?

_____

_____

_____

4. The single "sandwich" is referred to as a cell. What would the "double sandwich" be called?

_____

_____

5. In the dry cell, _____ energy is being converted into _____ energy.

6. For a cell to work, the electrodes must consist of two _____ metals and an _____.

7. To make a battery, you would connect the positive terminal of one cell to the _____ terminal of another cell.

Check your answers with your learning facilitator.

End of Part A

Part B

Investigation

Problem

How can you use a pencil to control the brightness of a light bulb?

Materials

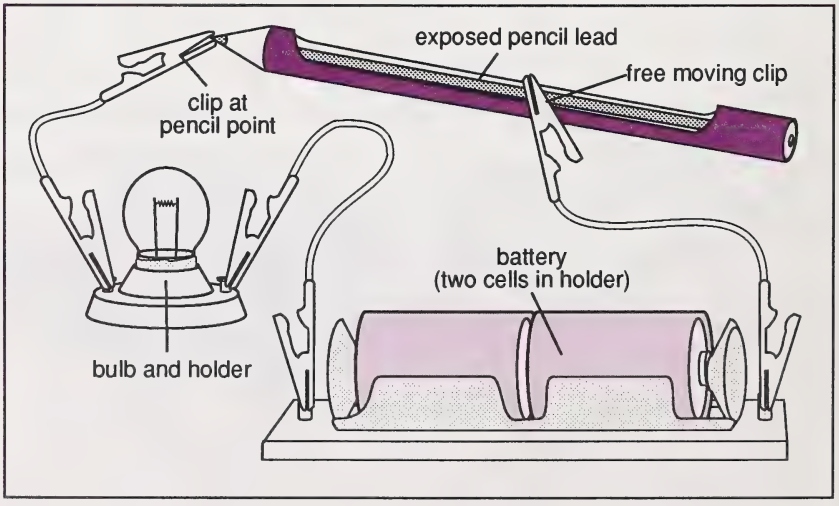
- connecting wires with clips
- two D-size cells in a holder
- 3 V light bulb in a holder
- soft lead pencil (such as HB)
- knife

Procedure

- Collect the materials required for this investigation.

Caution: Be careful with the knife. Always cut away from your hand and yourself. Use only a knife provided by your learning facilitator.

- Cut the wood from one side of the pencil.
- Connect all the materials as shown in the following diagram.



8. Slide the free clip up and down the exposed pencil lead. Record what you observed.

_____

_____

_____

_____

9. Why did the light bulb grow brighter and dimmer?

_____

_____

_____

10. What do you think would happen if you used copper wire instead of a graphite pencil?

_____

_____

_____

Check your answers by turning to the Appendix, Section 2: Extra Help.

End of Part B

Enrichment

In this section you learned that if you increase the resistance, heat or light will be produced. With this knowledge you will be able to build a model of an electric water heater.

9
Science Directions

Investigation

Refer to Activity 4-10 on page 194 in your textbook.

- Collect all the materials for this investigation. You may use tape to support your test tube in an upright position if you are unable to obtain the support stand and clamp.

1. What is the problem for this investigation?

_____

_____

- Complete steps 1 to 3 of the procedure.
- Do steps 4 to 7 of the procedure.

2. Use the data table on the next page to record temperature.

3. Complete question 1 of Analysis.

_____

4. What property of the nichrome wire allowed you to heat up the water?

_____

_____

5. Name some household appliances that use this same property.

_____

_____

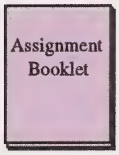
_____

Check your answers with your learning facilitator.

Data: Rate of Temperature Increase Due to Current Through a Nichrome Wire		
Time (min/sec)	**Temperature °C**	**Comments**
0:00		
0:30		
1:00		
1:30		
2:00		
2:30		
3:00		
3:30		
4:00		
4:30		
5:00		

Conclusion

The properties of some substances can be used to control the supply and transmission of electricity. You have seen how electricity can be created from chemical energy. You discovered that an electrical cell needs two different metals for the electrode and a liquid chemical for the electrolyte. While experimenting with wire, you found that resistance to the flow of electricity produces heat and light. These and other important characteristics of materials can be used to create many useful devices.



ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 2.

Section

3

Generating Electricity

DAVE MORRIS

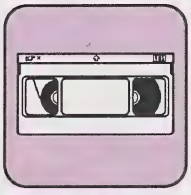
In the last section you saw how an electrical current can be made from chemical energy. There are a lot of electrical devices that use cells or batteries. However, most electrical appliances do not run on batteries. Can you imagine what it would be like if they did? Fortunately, electricity can also be made using other technologies and other sources of energy. In this section you will find out how this is done.

Activity 1: Using Motion to Produce Electricity

Electricity is important to the operation of your household. You know that electricity comes to your house along wires, but do you know where it comes from?

Do Part A or Part B, or both.

Part A



Watch the videotape *Electricity*. Then answer the questions following Part B.

Part B

Read page 186 of your textbook.

End of Part B

1. How is most of the electricity that you use in your house produced?

   _____

   _____

2. Batteries convert chemical energy into electrical energy. Another way of making electricity is by converting _____ energy into _____ energy.

Check your answers by turning to the Appendix, Section 3: Activity 1.

When you constructed your galvanometer, you saw that a magnetic field is produced by a wire that carries an electric current. Amazingly, this also works in reverse! A tiny pulse of electricity is produced when a strong magnet is passed close to a coil of wire. This important discovery is used to generate electricity.

9
Science Directions

Investigation

Refer to Activity 4-6 on page 187 in your textbook.

3. What is the problem for this investigation?

_____

_____

- Collect all the materials that are needed for this investigation. Since you will be producing only weak electric currents, a galvanometer works best to detect the current. However, if a galvanometer is not available, you may try using an ammeter or multimeter in place of a galvanometer. The magnet for this investigation does not have to be bar-shaped. In order to move the magnet through the coil, you may have to attach the magnet to a strip of cardboard.
- Complete steps 1 to 4 of the procedure to set up the apparatus.
- Do steps 5 to 8 of the procedure. If the poles are not marked, apply the procedure to opposite sides of the magnet, rather than the north and south poles.

4. Use the following data table to record the galvanometer readings. You may use the information given under question 1 of Analysis as a guide on how to complete the table. (If you are using a digital multimeter instead of a galvanometer, your readings may be stated in numerical values.) Describe how you moved the magnet around the coil. The first example is given.

Data: Comparing the Position of the Magnet and the Amount of Current Produced in the Coil

Position and Movement of Magnet	Instrument Reading	
	50 turns (step 2)	_____ turns (step 8)
north pole outside coil moved slowly		

Data: Comparing the Position of the Magnet and the Amount of Current Produced in the Coil		
Position and Movement of Magnet	Instrument Reading	
	50 turns (step 2)	_____ turns (step 8)

5. Does it matter if the bar magnet or the coil moves?

_____

_____

_____

6. Complete question 2 of Further Analysis.

_____

_____

_____

_____

_____

_____

7. Do question 3 of Further Analysis.

8. Do question 4 of Further Analysis.

Check your answers with your learning facilitator.

Activity 2: Using a Generator

You will now use what you learned in the last activity to make some predictions about how a generator works.

Investigation

Do either Part A or Part B.

Do Part A if you can obtain a small hand-held generator. Otherwise, do Part B.

Part A

Refer to Activity 4-7 on page 188 in your textbook.

- Collect all the materials that are needed for this investigation. You may use an ammeter or multimeter in place of a galvanometer.

1. Do steps 1 and 2 of the procedure. Then record your results.

_____

_____

_____

_____

2. Do step 3 of the procedure. Then record your results.

_____

_____

Discuss your observations with your learning facilitator.

End of Part A

Part B

Use an encylopedia or a book about electricity to do some research about generators.

End of Part B

3. Do question 1 of Analysis on page 188.

_____

_____

4. Do question 2 of Analysis.

_____

_____

_____

5. Based on what you learned in the last two investigations, what do you think are the two main components in a generator?

_____

_____

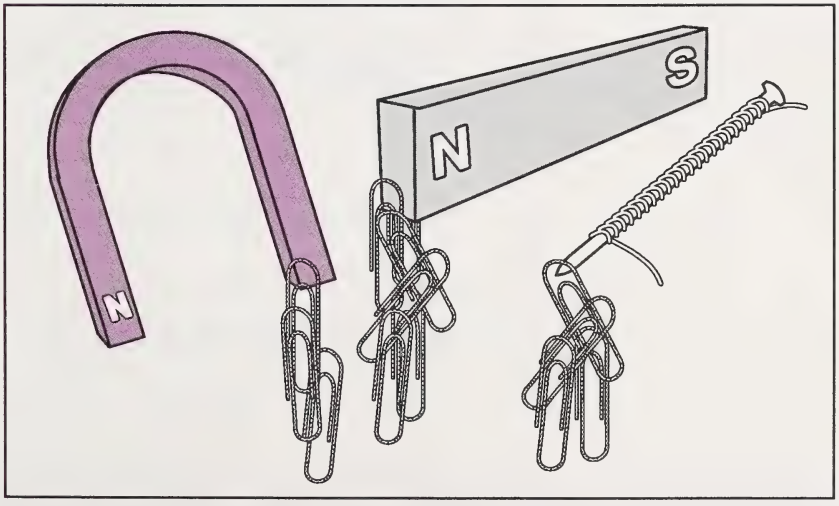
_____

Check your answers by turning to the Appendix, Section 3: Activity 2.

The relationship between electricity and magnetism is important. You have just seen how magnets use mechanical energy to produce electricity. Soon you will see how electricity can be used to power machines.

Activity 3: Making an Electromagnet

You are now going to take a closer look at different types of magnets.



9 Science Directions

Read about different types of magnets on page 188 in your textbook.

1. What are the two different types of magnets?

_____

_____

Check your answer with your learning facilitator.

Investigation

9 Science Directions

Refer to Activity 4-8 on page 189 in your textbook.

2. What is the problem for this investigation?

_____

_____

- Collect all the materials that are needed for this investigation.
- Complete steps 1 to 3 of the procedure.

3. Record how many degrees the compass needle deflected from its north-south position.

_____

_____

- Do step 5 of the procedure.

4. What did you observe with the iron spike?

_____

_____

- Do step 6 of the procedure.

5. What did you observe when you doubled the number of turns of wire?

_____

_____

- Do step 7 of the procedure.

6. What did you observe with forty turns of wire and one extra electrical cell?

_____

_____

- Do step 8 of the procedure.

7. How could you improve on your electromagnet to increase its lifting strength?

_____

_____

_____

_____

_____

_____

_____

8. Do question 3 of Further Analysis.

_____

_____

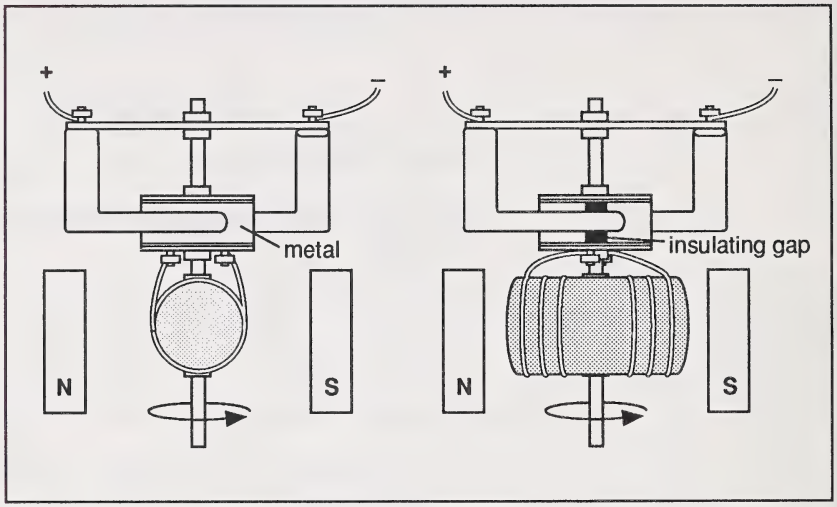
_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 3.

Activity 4: How a Simple Electric Motor Works

You should now have a basic understanding of how electricity is produced with a generator. A generator needs a magnetic source, a coil of wire, and some type of motion by which the two will affect each other. An electric motor is almost the same as a generator. Instead of converting mechanical energy into electrical energy, it does the reverse. By studying an electrical motor, you can also see how a generator works.



Read the first three paragraphs on page 190 in your textbook.

1. As you read the passage in your text, you found out that electromagnets have a north and south pole. What happens to the poles if you reverse the direction of current flowing through the electromagnet?

_____

_____

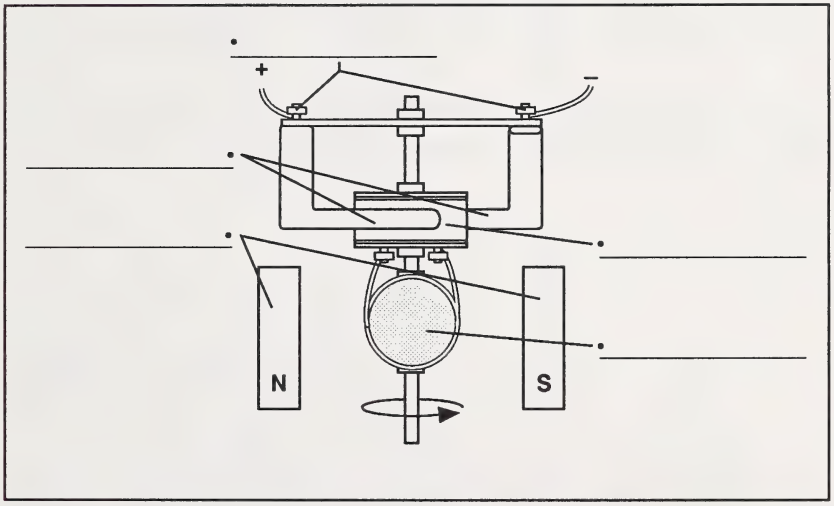
_____

Read the last paragraph on page 190 in your textbook.

2. The armature is the same as an _____.

3. Label the diagram using the following terms.

- permanent magnets
- armature
- brushes
- split ring commutator
- battery terminals



Check your answers with your learning facilitator.

Closely examine the preceding diagram, as well as the one on page 190 of your textbook. You will notice that each of the two wires from the armature are connected to each of the half-rings of the commutator.

Read the first paragraph of page 191 in your textbook.

4. Assume that electricity moves from the negative terminal to the positive terminal. Describe the path of electrical current from one battery terminal to the other terminal when the brushes are in contact with the metal in the commutator. You may wish to use a flow diagram.

9 Science Directions

Read and look at diagram (a) on page 191 of your textbook. Use the diagram to answer questions 5 and 6.

5. As the current begins to flow through the armature, End A becomes the _____ pole.

6. What happens to the armature? Explain.

9 Science Directions

Read and look at diagram (b) on page 191 of your textbook. Use the diagram to answer question 7.

7. As the armature turns, the brushes come in contact with the insulating gap. Is there any current flowing through the armature at this time?

_____

9 Science Directions

Read and look at diagram (c) on page 191 of your textbook. Use the diagram to answer questions 8 and 9.

8. As the armature turns further around, the brushes come in contact with the other side of the split ring metal commutator. What happens to the direction of current flow in the armature?

_____

_____

9. End A of the armature now becomes the _____ pole.

The steps continue to repeat themselves until the electrical current stops.

Check your answers with your learning facilitator.

Activity 5: Electricity and Heat Energy

So far you have seen that cells convert chemical energy into electrical energy, and that generators convert mechanical energy into electrical energy. You have also seen that electrical motors convert electrical energy into mechanical energy. Another way that electricity can be converted is through a process that you encounter almost every day. This is the conversion of electricity to heat, or thermal energy. As in motors or generators, the conversion process can occur in either direction.

9 Science Directions

To find out more about this process, read page 193 in your textbook.

1. What does a thermocouple do?

_____

_____

9
Science Directions

Investigation

Refer to Activity 4-11 on page 195 of your textbook.

Caution: Do this activity under the supervision of a learning facilitator.

In this investigation you will have a chance to construct a thermocouple and see that electrical energy can be obtained from the device.

- Collect all the materials that are needed for this investigation. Use a piece of fine sandpaper to remove any plastic coating from the coat hanger.
- Do steps 1 to 5 of the procedure.

2. Record the results from steps 3 to 5 in the following table.

Data: Current Produced by Thermal Effects		
Steps	**Instrument Reading**	**Comments**
3 (before heating)		
4 (while heating)		
5 (while cooling)		

3. Do question 1 of Analysis.

4. Do question 2 of Analysis.

5. Does a thermocouple produce a lot of electricity?

6. Make a list of some practical applications for a thermocouple.

Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

One of the main ideas that you need to understand in an electric motor is how the electromagnet in the armature functions.

Investigation

Problem

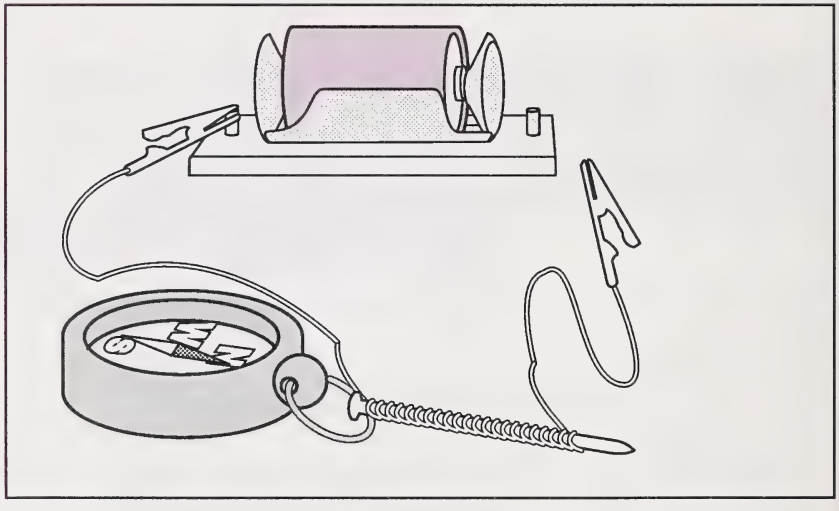
Do the poles of an electromagnet reverse when the electrical current flowing through the electromagnet is reversed?

Materials

- simple electromagnet made from a nail with twenty turns of wire wrapped around it
- two connecting wires with clips
- one D-size cell (with holder)
- a compass

Procedure

- Connect the materials as shown in the following diagram.



- Place the electromagnet beside the compass and connect the two wires to the battery. The compass needle is a permanent magnet. The south end of the needle should point to the north end of the electromagnet.

1. Which end of the compass needle points to the nail?

- Now reverse the connection on the battery.

2. Which end of the nail does the needle point to now?

- Quickly repeat the process several times to see if you can get the compass needle to swing in circles.

3. What happens to the poles of an electromagnet when the current is reversed?

4. Write a paragraph to briefly explain how an electric motor works.

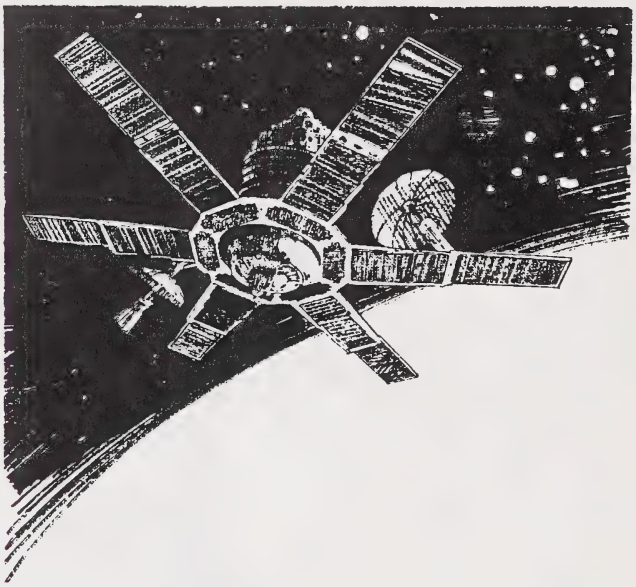
Check your answers with your learning facilitator.

Enrichment

This activity describes two other ways of producing electrical energy. One method involves the conversion of light energy, and the other method involves the conversion of sound energy.

9
Science Directions

Read page 196 in your textbook.



1. Where do people use solar energy?

Check your answer by turning to the Appendix, Section 3: Enrichment.

Do either Part A or Part B, or both.

Do Part B if you are able to obtain a solar cell. Otherwise, do only Part A.

Part A

Use an encyclopedia or other reference book to research the use of solar energy. Then answer the questions following Part B.

Part B

Investigation

Refer to Activity 4-12 on page 197.

2. What is the problem in this investigation?

- Collect all the materials required for this investigation. You may use an ammeter or multimeter in place of a galvanometer.
- Do step 1 of the procedure.

3. What was the reading on the galvanometer with the light on?

4. What was the reading on the galvanometer with the solar cell covered?

- Do steps 2 to 4 of the procedure.

5. Use the following data table to record your results. Specify the units of measurement.

Data: The Effect of Distance from a Light Source on the Electrical Current Produced by a Solar Cell	
Distance of Light Source (cm)	**Instrument Reading**
(double)	
(triple)	

- Do step 5 of the procedure.

6. What was the reading on the galvanometer with two light bulbs?

7. Do question 1 of Analysis.

Discuss your answers with your learning facilitator.

End of Part B

9 Science Directions

8. Do question 2 of Analysis on page 197 of the textbook.

_____

_____

_____

_____

9. Do question 3 of Further Analysis.

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 3: Enrichment.

9 Science Directions

Read page 198 of your textbook to find out about electricity and sound.

10. What is the proper name for the conversion of sound waves into electrical current?

_____

_____

11. What devices do you use that convert sound wave into electrical energy, or electrical energy into sound waves?

_____

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 3: Enrichment.

Conclusion

In this section you looked at several ways of producing electrical energy. Electricity was produced using mechanical energy when a magnet was set in motion near a coil of wire. You then found that the poles of a magnet will reverse if the flow of electricity is reversed. You saw how these two concepts have been combined to construct electric generators and electric motors. Both of these machines demonstrate how other forms of energy can be converted into electrical energy and back again!

Electricity can also be produced from heat energy in a thermocouple . A solar cell can produce electricity using light energy.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 3.

Section

4

Circuits and Switches

DAVE MORRIS

Have you ever noticed that some whole strings of Christmas lights will go out when one bulb is removed? On other strings this does not happen. Why is this so?

Have you ever wondered how it is possible to turn the same light bulb on and off from two different locations?

In the last two sections you dealt with the production of electricity. Now that you have this electrical energy, you must be able to control it. You have to make electricity do what you want it to do when you want certain things to happen. In this section you will try to control electricity in a variety of ways.

9 Science Directions

Activity 1: Series and Parallel Circuits

Read page 200 of your textbook for an introduction to circuits.

1. Define the following terms.

   a. electric circuit:

   _____

   _____

   b. open circuit:

   _____

   _____

   c. closed circuit:

   _____

   _____

   d. switch:

   _____

   _____

2. Define the following subsystems found in an electrical circuit system.

   a. source:

   _____

   _____

   b. conductor:

   _____

   _____

   c. control:

   _____

   _____

d. load:

_____

_____

3. In your own words describe the difference between a series circuit and a parallel circuit.

_____

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 4: Activity 1.

In the following investigation you will investigate the properties of a series circuit.

Investigation

Refer to Activity 4-13 on page 201 of your textbook.

- Collect all the materials that are needed for this investigation. You can substitute a scissor switch for the push-button switch. See Activity 2 if you do not have a ready-made switch. In the next activity you will see how you can make a homemade switch.

- Do steps 1 to 3 of the procedure.

4. What did you observe about the brightness of the light each time you added another light bulb?

_____

_____

_____

_____

_____

- Do step 4 of the procedure.

5. What happens when one of the light bulbs is unscrewed?

6. Do question 4 of Further Analysis.

Discuss your answers with your learning facilitator.

7. What are the two main principles of a series circuit?

Check your answers by turning to the Appendix, Section 4: Activity 1.

In this next investigation you will investigate the principles of a parallel circuit.

Investigation

Refer to Activity 4-14 on page 202 in your textbook.

- Collect all the materials that are needed for this investigation. You may substitute a scissor switch for the push-button switch. A switch that you have made may also be substituted.

- Do steps 1 to 3 of the procedure.

8. Describe any changes in the brightness of the lamps as you added more light bulbs to the circuit.

- Do step 4 of the procedure.

9. What happens when one of the light bulbs is unscrewed?

Discuss your answers with your learning facilitator.

10. Complete question 3 of Further Analysis.

Textbook question 3. (a):

Textbook question 3. (b):

11. Complete question 4 of Further Analysis.

12. What are the two main principles of a parallel circuit?

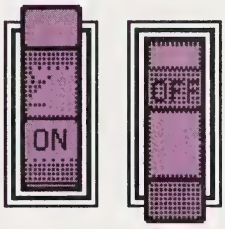
13. Complete question 5 of Further Analysis.

Textbook question 5. (a):

Textbook question 5. (b):

Check your answers by turning to the Appendix, Section 4: Activity 1.

Activity 2: Using Switches



Now you have a good idea of how the two types of circuits work. Next you need to look at how to open and close a circuit to turn it off and on when you want.

Investigation

Refer to Part B of Activity 4-15 on page 203 in your textbook.

1. What is the problem for this investigation?

_____

_____

- Collect the materials that are required for this investigation.
- Do steps 1 and 2 of the procedure.

2. When the circuit is first completed, the bulb is _____ (on, off).

- Do step 3 of the procedure.

3. After connecting the switch as shown in diagram (b), the bulb is _____ (on, off).

4. After connecting the switch as shown in diagram (c), the bulb is _____ (on, off).

5. Explain why the light can be turned on or off with either of the two switches.

_____

_____

_____

Check your home to see how many two-way switches you can find.

6. Where in a home would you encounter such a wiring arrangement?

Share your answers with your learning facilitator.

The convenience of two-way switches makes them a feature in almost every home. Another common switch is often connected to a doorbell that can be operated from a front door or a back door. The next investigation will demonstrate how this is done.

Investigation

Refer to Part C of Activity 4-15 on page 204 in your textbook.

7. What is the problem for this investigation?

- Collect all the materials that are required for this investigation.
- Do steps 1, 2, and 3 of the procedure.

8. What happens to the door bell in each of the following situations?

   a. Each button is pushed at different times.

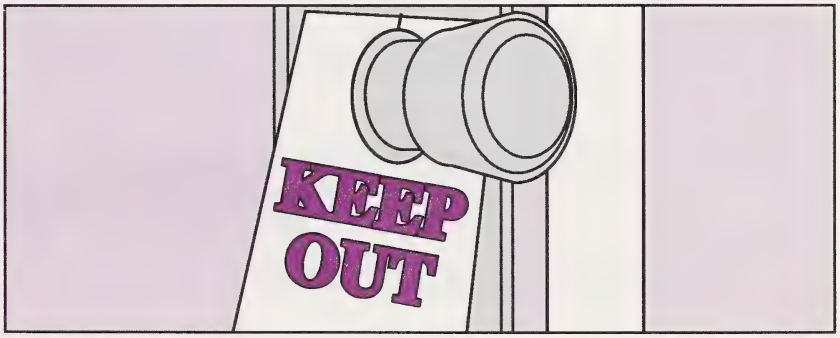
b. The buttons are pushed at the same time.

Check your answers with your learning facilitator.

The circuit used for a doorbell can also be used to make a burglar alarm. In the next investigation you will build an alarm that could even be used for your room!

Investigation

Refer to Part D of Activity 4-15 on page 204 in your textbook.



9. What is the problem in this investigation?

- Collect the materials that are required for this investigation.
- Do steps 1, 2, and 3 of the procedure.

10. Draw a circuit for a burglar alarm that you could make for your bedroom door. Explain briefly how it would work.

Share your plans with your learning facilitator.

Activity 3: Electromagnetic Switches

You saw in the last activity that some very simple devices can be used to turn an electrical device on and off. The use of electromagnets in switches enables you to use electricity in a lot or other ways.

Investigation

Problem

How can you make a simple **electromagnetic switch**?

Electromagnetic switch: a switch that uses an electromagnet to provide its force to activate the switch

Materials

- switch
- one 2 cm wood screw
- one small flat-head wood screw
- screwdriver
- 1 m of 26 gauge insulated or coated copper wire
- six connecting wires with clips
- one D-sized cell in holder
- two D-sized cells in holder
- 1.5 V bulb in socket
- small block of wood that measures 10 cm × 10 cm
- strip of tin (1 cm × 10 cm)
- 5 cm common nail

Procedure

Collect the materials that are required for this activity.

Construct the electromagnetic switch as follows:

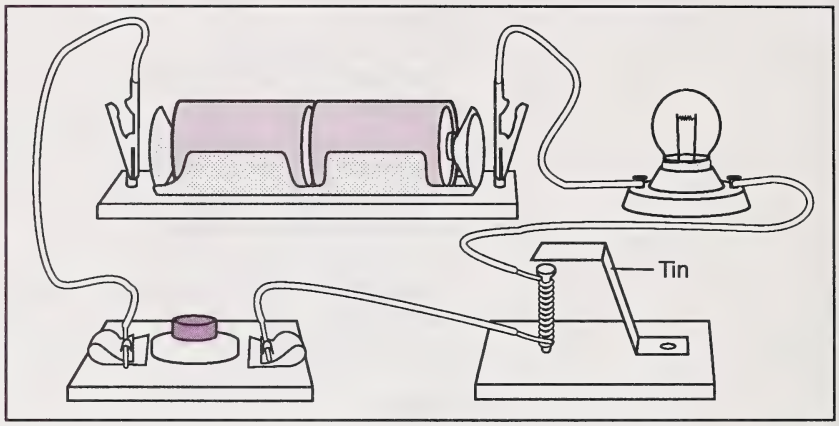
- Drill a hole in the wooden block. The hole should be slightly smaller than the diameter of the nail. Gently hammer the nail into the wood.

- Make an electromagnet by wrapping at least forty turns of insulated or coated copper wire around the nail. Strip 3 cm of insulation from the ends of the wire for attachment into the circuit.

- Use tin snips to cut a strip of tin (1 cm × 10 cm) from a lid of a fruit or vegetable can. Be careful not to cut yourself on the sharp edges!

- Carefully bend the tin strip into the shape shown in the diagram and attach it to the wooden block with a small flat-head wood screw.

- Connect the rest of the circuit as shown.



1. What happened to the electromagnet and the light when the circuit was connected?

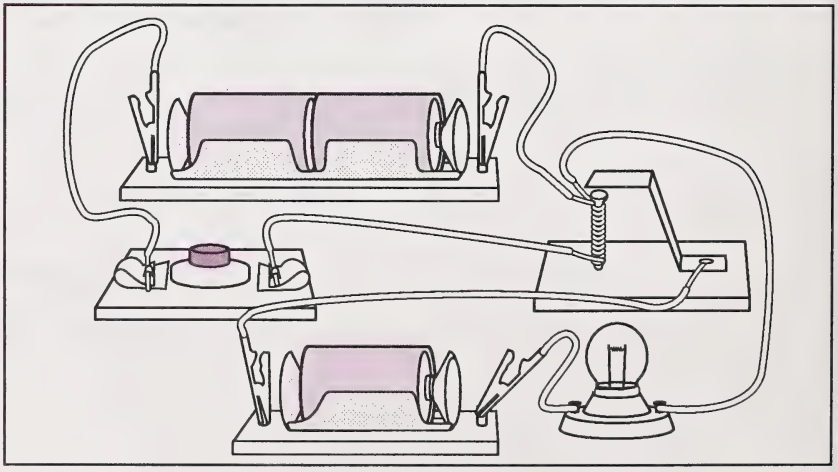
_____

_____

_____

- If nothing happened, check all the connections. Try bending the tin so that it is closer to the top of the nail. Now you should be able to answer question 1.

- Now reconnect the wires as shown in the next diagram.



- Close the switch.

2. What happened to the electromagnet and the light when the switch was closed?

- Disconnect the light from the cell.

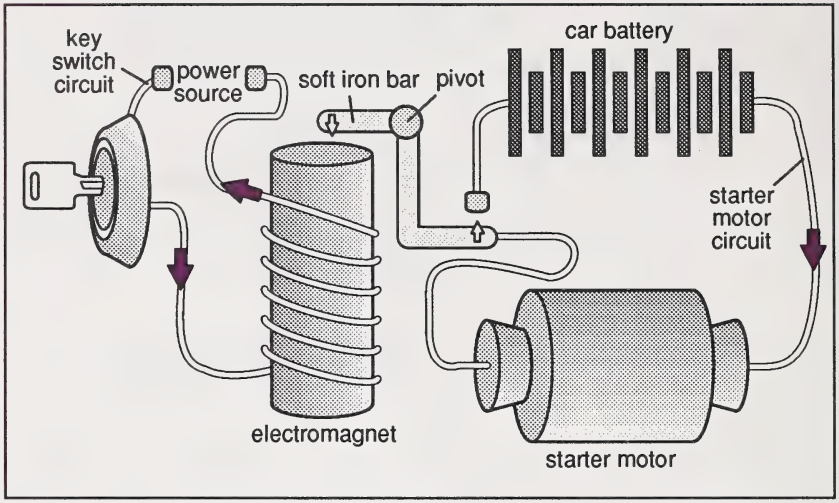
3. What happened to the electromagnet and the light when the light was disconnected?

4. What made the metal strip touch the nail?

5. Is the light in the second circuit receiving its electricity from the same cell as the electromagnet?

Relay: a special type of electromagnetic switch that allows lower voltages and smaller switches to be used in control circuits

Electromagnetic switches are found in devices called **relays**. The purpose of relays is to isolate one circuit from another. A relay is used to start a car. The switch circuit has a low amperage which would not harm you if there was a short. On the other side of the relay is the starter motor. The starter motor requires a high amperage and can be very dangerous. Look at the following diagram.



6. Give another example of where an electromagnetic switch or relay is used.

Check your answers with your learning facilitator.

9
Science
Directions

Activity 4: Circuit Diagrams

You probably have your own ideas about how to draw or describe an electrical circuit. Yet, it is very important that people around the world communicate their ideas with each other. For this reason, you should use standard symbols to draw a circuit that you would like someone else to put together.

Read page 205 of your textbook to find out what some of these symbols are.

1. For each of the following items, draw the symbol that would be used to represent it.

cell – show the positive (+) and negative (–) ends
battery – show the positive (+) and negative (–) ends
lamp

resistor
switch
galvanometer
variable resistor
motor

Check your answers by turning to the Appendix, Section 4: Activity 4.

Investigation

Problem

How can you use symbols to show electrical circuits?

Materials

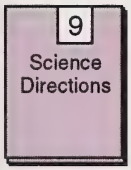
- three 3 V light bulbs in sockets
- two D-size cells in a holder
- two switches
- eight connecting wires and clips
- 30 cm of nichrome wire
- buzzer or bell (optional)

Procedure

- Collect the materials that are required for this investigation.

- Draw a circuit diagram for each of the following questions. Then test your drawing by arranging the actual materials as you drew them.

2. Go back to Activity 4-15 on pages 203 and 204. Use the proper symbols to redraw any two circuits from the activity. Create your own symbol for the doorbell.



3. Draw a circuit diagram that shows two light bulbs hooked in series with a switch and a two-cell battery.

4. Draw a circuit diagram that shows two light bulbs hooked in parallel with one switch and a two-cell battery. The switch must turn both lights on and off at the same time.

5. Draw a circuit diagram that shows two light bulbs hooked with two switches, a variable resistor, and a two-cell battery. The switches must turn both lights on and off at different times. The variable resistor must vary the brightness of the light. (Remember the nichrome wire.)

Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Investigation

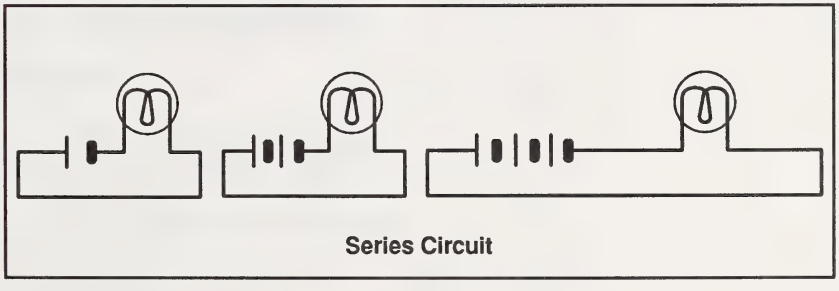
In this investigation you will review the characteristics of a parallel circuit and a series circuit.

Materials

- three 3 V light bulbs in sockets
- two D-size cells in holders
- one D-size cell in holder
- two switches
- eight connecting wires with clips

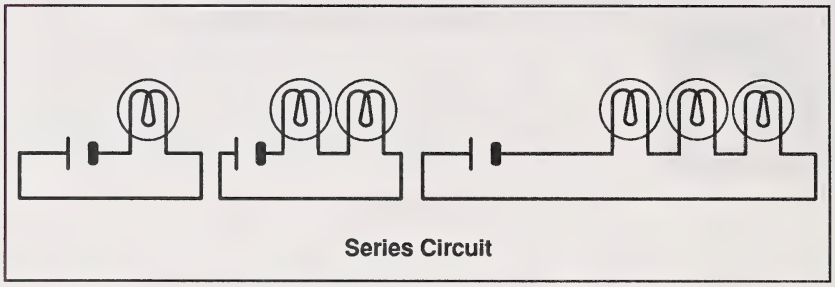
Procedure

Hook up the materials as shown in each of the following sets of circuit diagrams and observe the brightness of the light bulb.



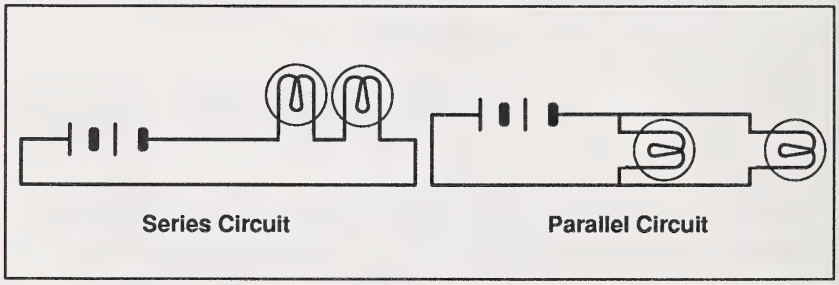
Series Circuit

1. How does the number of cells affect the brightness of the light bulb?



Series Circuit

2. How does the number of light bulbs affect the brightness of each individual light bulb?



Series Circuit Parallel Circuit

3. How does the brightness of the light bulbs compare in the two circuits?

Using the same set-up as shown in the last circuit diagram, disconnect one light bulb in each circuit.

4. What happens when one light bulb is disconnected from each circuit?

Check your answers by turning to the Appendix, Section 4: Extra Help.

Enrichment

Investigation

In this investigation you will design and construct specific circuits that will be able to accomplish a specific task.

Materials

- three 3 V light bulbs in sockets
- two D-size cells in holders
- two switches
- eight connecting wires with clips

Procedure

Draw a circuit diagram to solve each of the following problems. Then test your design. You can change your design during the testing to get the best possible solution.

1. Design a circuit which has three light bulbs and meets the following conditions:

    - If bulb 1 is unscrewed, then bulbs 2 and 3 stay on.
    - If bulb 2 is unscrewed, then bulbs 1 and 3 stay on.
    - If bulb 3 is unscrewed, then bulbs 1 and 2 go out.

2. Design a circuit which has two light bulbs and two switches and meets the following conditions:

    - If both switches are open, both lights are off.
    - If either of the switches are closed, both lights come on.

Check your answers by turning to the Appendix, Section 4: Enrichment.

Conclusion

In this section you have seen how to make electricity do what you want it to do. You have become familiar with two basic types of circuits (series and parallel) that each have specific abilities. You have solved some basic circuit problems. You have also learned some of the basic symbols that are important when you are communicating your ideas about electricity.

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 4.

Assignment Booklet

Section

5

Electricity in the Home

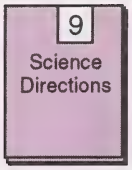
DAVE MORRIS

Power at the press of a button or the flip of a switch! How often do you find yourself taking all this for granted?

In the previous sections you found out what electricity is and how to control it. In this section you will see how electricity is safely brought into your house. You will also review your personal safety habits. Electricity can be dangerous if you do not handle it properly. Later in this section you will be challenged to solve some wiring problems by using the skill and knowledge you have developed in this module.

Activity 1: A Safe Supply of Electricity

Have you ever wondered how electricity is brought safely into your home? Have you ever plugged one too many things into an electrical outlet and lost power completely? What stopped the electricity from flowing?



Read pages 212 and 213 of your textbook to find the answers to these questions.

1. What are the three wires that come into the house and what do they do?

   _____

   _____

   _____

   _____

   _____

2. When the wires first enter the house, they go through a _____.

   The purpose of this device is to keep track of _____

   _____

   _____.

3. Electricity next enters the _____. This device has two functions which are _____

   _____

   _____.

4. What is the main purpose of fuses and circuit breakers?

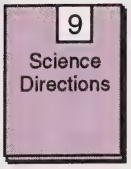
   _____

   _____

   _____

   _____

Check your answers by turning to the Appendix, Section 5: Activity 1.



Read page 214 of your textbook.

5. Describe how a fuse works.

6. Describe how a circuit breaker works.

7. If a 20 A fuse blows, should you replace it with a 30 A fuse? Explain your answer.

8. What should you do before you replace a blown fuse?

9 Science Directions

Look at the pictures on page 215 of your textbook.

9. Write a safety rule for each of the pictures.

top left:

_____

_____

top right:

_____

_____

bottom left:

_____

_____

bottom right:

_____

_____

Did you think that you were in danger of being electrocuted while you were making circuits with just a few cells? In this module you have experienced that you could safely use bare hands on connecting clips and on cell terminals. However, you must be very careful not to touch any conductor carrying a current when using household electricity.

10. Why do you think there was no danger of getting a shock while doing the previous investigations?

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 5: Activity 1.

A rule of thumb is that a voltage of over 25 V is potentially dangerous, and a voltage below 25 V is not. For example, you could touch both terminals of a 12 V car battery at the same time with wet hands and not be electrocuted! Don't do it though, because there is likely some dangerous acid on the terminals. The current measurements that you made in the investigations were well under 1 ampere. A car battery is capable of putting out 300 A of current while starting a car. In spite of the battery's current capacity, its terminal cannot give you a shock.

On the other hand, an electrical circuit in your house can be deadly, even when controlled by a 10 A fuse. If you personally complete the circuit, the voltage of 110 V is enough to push current through you. Only a small current flow is needed for a deadly effect – a third of an ampere may do.

Transformer: a device used to increase or decrease the voltage in a circuit

An electric doorbell operates at a voltage under 25 V. The electricity is brought to a safe level by means of a **transformer**. In the same way the current that operates a model electric train is applied through its metal tracks. The electricity comes from a transformer which converts 110 V to a lower level. Even if you touch both tracks at the same time, you will not be electrocuted.

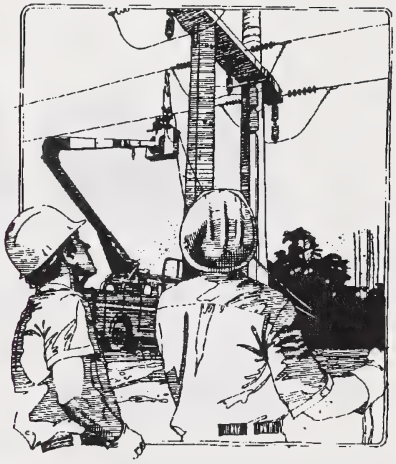
Although the voltage of a device can indicate the danger of electrocution presented by that device, the amperage is also important. Do you remember the investigation in which you related the bulb brightness to current flow? You found out that the greater the current, the brighter the light. More generally, the greater the amperage of a device, the more energy it gives off. If the energy is given off as heat, you can be burned. Both a toaster and an electric frying pan are rated at about 10 A. As you know, these appliances can give off very much heat.

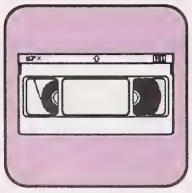
It takes only a few high-amperage devices on the same household circuit to throw a circuit breaker. If the circuit breaker is faulty, these high-amperage devices can cause overheating of the electrical wires of the circuit and cause an electrical fire.

When cells are connected end-to-end so that the negative terminal of one cell touches the positive terminal of the next cell, they are connected in series. The voltage produced by cells connected in series is equal to the sum of the voltages of the individual cells. A D-size cell has a voltage of 1.5 V.

11. What is the maximum number of D-size cells that can be connected in series without producing a potential danger for electric shock?

A special danger is presented by high-voltage power lines. This electricity will find any pathway to the ground unless prevented by insulators.





If you can, obtain the videotape *Volton* to learn more about these hazards.

12. Use your knowledge of current flow to explain why a bird sitting on a 10 000 V power line does not get electrocuted.

13. What would happen if the bird touched the transmission tower at the same time?

_____

_____

_____

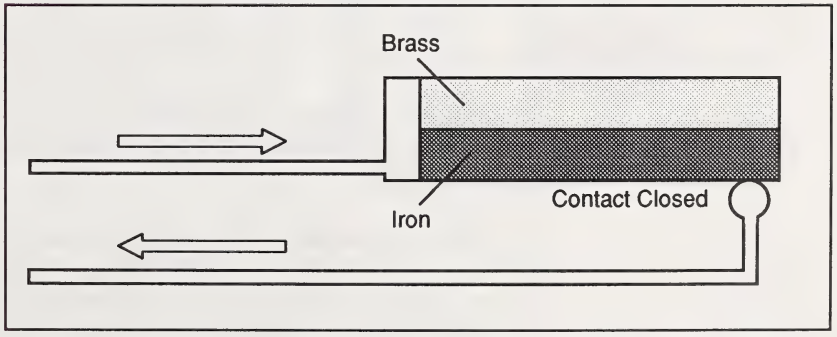
Check your answers by turning to the Appendix, Section 5: Activity 1.

Activity 2: Common Household Appliances

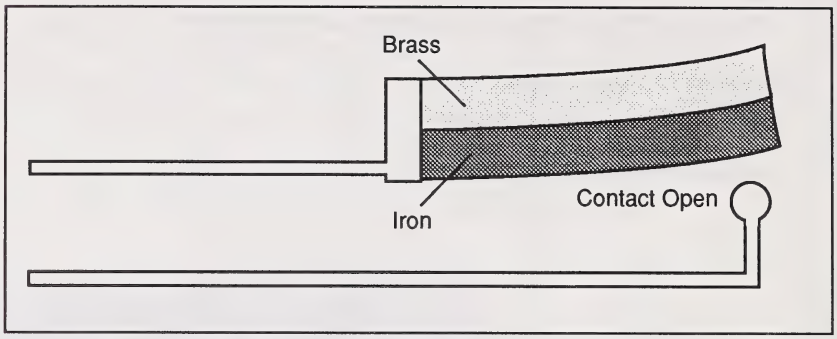
All devices that use electricity can be classified as electrical-mechanical systems. Within each system is a series of subsystems working together. In this activity you will be looking at some common household appliances. You will analyse their subsystems to gain a better understanding of how they work.

Bimetallic strip: a strip or coil composed of two different metals that bends in response to temperature change

One of the most important devices used in appliances is something called a **bimetallic strip**. Just as the word indicates, it contains two different metals stuck together. The metals are usually brass and iron. Because of different heating properties, they expand and contract at different rates. This causes the metal strip to bend towards the metal that expands the least when heated. The bending can be used to act as a heat-activated switch.



Switch Closed: The metal strip is straight allowing electricity to flow through it.



Switch Opened: The metal strip has been heated, causing it to bend. There is no contact; therefore, the electricity cannot flow.

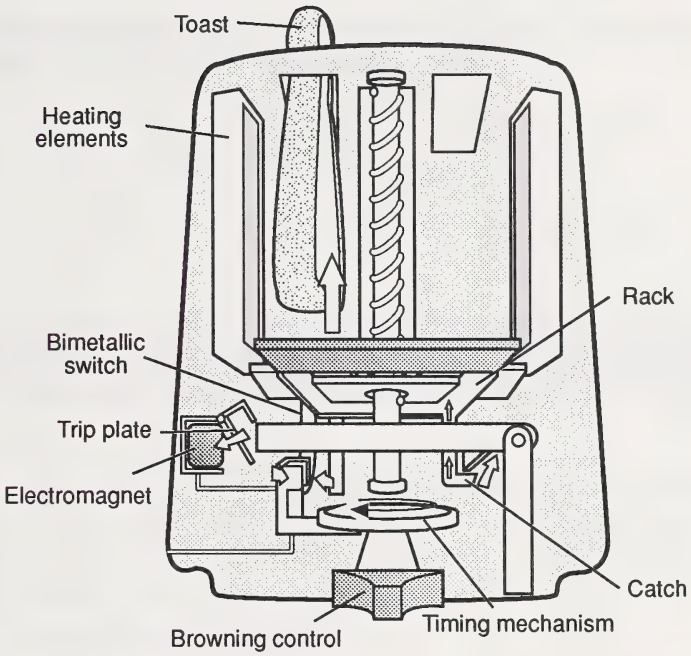
Thermostat: a type of switch used to regulate temperature by turning cooling or heating devices on or off

Any device that uses a **thermostat** will more than likely contain a bimetallic strip.

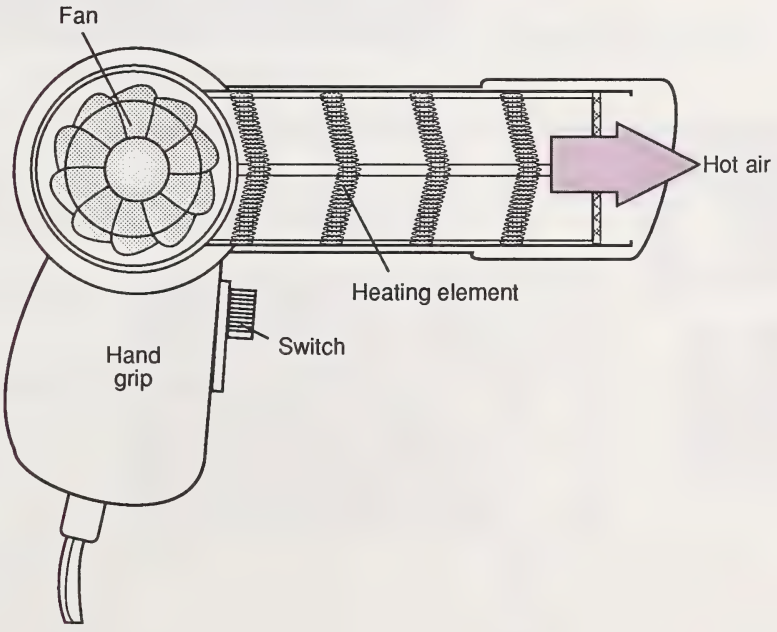
1. What are some devices that would use a bimetallic switch?

Using the following diagram, look for the subsystems of a toaster as described in the following paragraph. Use a real toaster if you wish, but do not plug it in or disassemble it.

The toast is placed on a rack that is spring-loaded. When the rack is lowered, it hooks on to a catch and a switch is triggered, causing the heating element to go on. A bimetallic switch turns off the heating element at a certain temperature. This is adjusted by moving the browning control. When the bimetallic switch turns off, it also turns on an electromagnet. The electromagnet pulls a trip plate, releasing the spring-loaded rack off the catch. Up comes your toast!



Examine the following diagram of the hair dryer and try to locate the subsystems.



2. Now it is your turn. Using the diagram of the hair dryer, explain how it works. You can use a real dryer to look at. Do not plug it in and do not disassemble it.

Check your answers by turning to the Appendix, Section 5: Activity 2.

Activity 3: Be an Inventor

Now you will have a chance to apply your knowledge of electricity while inventing a new device.

Read page 207 of your textbook. Focus on the inventions at the bottom of the page.

1. What are the two main subsystems in the mousetrap?

2. Since mice come out only at night, what could you do to the mousetrap so that it only works when it is dark out?

_____

_____

_____

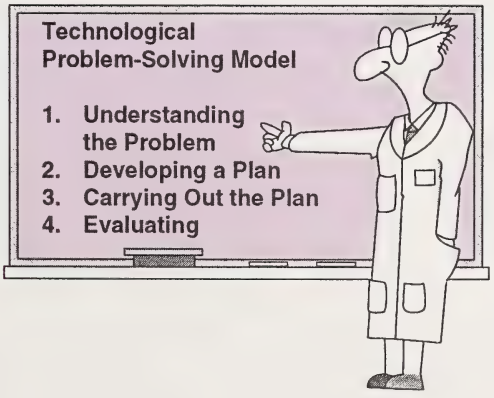
_____

Check your answers by turning to the Appendix, Section 5: Activity 3.

Now it is your turn. Invent a device that will perform at least two functions. Your invention can do two things at once, or do one thing and then trigger something else to happen afterwards. You will not have to build it. Here are a few suggestions:

- a light-triggered burglar alarm
- a house light that automatically turns on at night and off in the morning
- a curling iron that is activated by sound
- an automatic heater that will turn on at a certain temperature so that the water in a well will not freeze
- a garage-door opener that is activated by the light from a car headlight

See if you can come up with your own invention. The technological problem-solving model is included to help you get started.



3. What is your device going to do?

4. Sketch at least two ideas of how your device is going to work.

5. Make a circuit diagram of your invention. Use standard electrical symbols wherever possible. Also write a brief explanation of how the device works.

According to the technological problem-solving model, your next step would be to build your device. Although you are not required to build your invention now, you should realize that its development does not stop here.

6. What could you do during construction to improve your design?

The perfection of your design would not stop when the construction of a working model was completed. You would now evaluate your design. Problems could be corrected in future versions.

7. If you had a working model of your invention, describe how you could evaluate your design.

_____

_____

_____

_____

_____

_____

Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Use the clues to fill in the blanks. Then find the words in the word search puzzle.

1. a device that safely distributes electricity throughout the house

_____

2. a device that measures the amount of electricity that enters a house

_____

3. the wire that is electrically neutral

_____

4. the wires that carry electricity or are "live"

_____

5. a safety device that stops the flow of electricity when a thin piece of metal melts

_____

6. a safety device that stops the flow of electricity when a bimetallic switch heats up, bends, and turns a switch off

_____

U M X M L F Q F X K R
N L F X E O W X B C K
V G P Y N X D D B Q V
B P G Z A N K K S Z A
B Z B O P N V Y D V T
T C P D R Y E F O Z F
R G X B E I J B D I M
K E M C T D R E L W G
Q E T V S E N S F J S
I H B E A Q Q U T H Z
J M Z K M N J F O M C
J K E U O E G T V R Y
W R B P J E A A D M G

Check your answers by turning to the Appendix, Section 5: Extra Help.

Enrichment

1. Pick one of the following devices. Use your knowledge of electricity to draw the device and explain how it works.

   a. airport metal detector: a walk-through device that will detect whether you are carrying any metal objects

   b. traffic lights that can detect when a car has arrived at the intersection

2. Pick one of the following electrical appliances and see if you can figure out how it works.

kettle	record player
toaster oven	curling iron
thermostat	doorbell
oven	

To help you, you may want to look at an old appliance that no longer works. Make sure that you have permission to disassemble it.

Caution: Do not plug the appliance in while you are working on it. Do not use the appliance after it has been disassembled.

a. Draw and label the appliance you have chosen.

b. Write a paragraph to describe how the appliance works.

Check your answers with your learning facilitator.

Conclusion

In this section you looked at electrical safety in the home. Most safety rules use common sense. You also looked at some household electrical appliances to gain an understanding of how they work. You saw that they are made up of a series of subsystems that all work together to accomplish a task.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 5.

MODULE SUMMARY

Electricity is part of your everyday life. Most people could not go through a day without encountering a device that uses electricity.

This module showed you some of the reasons why electricity is so useful. You saw that electrical charges can produce pushing or pulling forces and magnetic fields.

You discovered the wide variety of ways of converting different forms of energy into electrical energy. Chemical cells convert chemical energy into electrical energy. For these cells to work, they need two electrodes of different metals and an electrolyte. Generators convert mechanical energy into electrical energy. Other forms of energy can also be converted into electrical energy, including light, sound, and heat. You also learned that electrical energy can be converted into other useful forms of energy such as mechanical energy, heat, light, and sound.

You learned how to control electricity to do things for you. You found that electricity flows along electrical circuits either arranged in series or parallel configurations. Special switches can be used to regulate the flow of electricity in a circuit.

You also looked at the safe use of electricity. You saw how fuses and circuit breakers function. You examined the electrical-mechanical systems in various household appliances.

In all, you found that electricity is probably the most useful form of energy available. Its applications are endless and its place in your future is certain.

Be sure to read page 216 in your textbook for examples of how electronics might find a place in your future career.

9 Science Directions

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the Final Module Assignment.

Appendix

Glossary

Ammeter	• a device that is used to measure current strength
Ampere	• a unit used to indicate the strength of an electrical current. The symbol for this unit is A.
Battery	• two or more electrical cells operating as a single source of electricity
Bimetallic strip	• a strip or coil composed of two different metals that bends in response to temperature change
Conductor	• any material that allows an electrical charge to travel through it
Electrical cell	• converts chemical energy to electrical energy by creating a flow of electrons from a positive electrode to a negative electrode
Electric charge	• the positive or negative charge on an object or particle that exerts an electrical force
Electrode	• the part of a battery that allows electrons to enter or leave
Electrolyte	• the solution in contact with the electrodes in an electric cell
Electromagnet	• a magnet created by passing a current through a coil surrounding an iron core
Electromagnetic switch	• a switch that uses an electromagnet to provide the force to activate the switch
Galvanometer	• a device used to detect and measure weak electrical current
Generator	• converts mechanical energy into electrical energy
Insulator	• a non-conductor
Multimeter	• a device that can be used to measure voltage, current strength, and resistance using different settings on the same instrument
Non-conductor	• any material that does not allow an electrical charge to travel through it

Parallel circuit	• an electrical circuit that contains more than one pathway for the current to follow
Relay	• a special type of electromagnetic switch that allows lower voltages and smaller switches to be used in control circuits
Resistance	• a measure of how much a material resists the flow of electricity. The unit is the ohm (Ω).
Resistor	• A device made of a material that has a specific resistance to the flow of electrical charge
Rheostat	• a device that has a controlled variable resistance to the flow of electrical charge
Series circuit	• an electrical circuit that contains a single pathway for the current to follow
Switch	• a device that closes and opens a circuit
Thermocouple	• a device that converts heat energy into electrical energy
Thermostat	• a type of switch used to regulate temperature by turning cooling or heating devices on or off
Transformer	• a device used to increase or decrease the voltage in a circuit
Volt	• a unit used to indicate the force caused by a difference of electrical charge that is capable of producing an electric current

Suggested Answers

Section 1: Activity 1

11. Positive and negative charges were observed.

12. The charged particle is called the electron.

13. • Opposite charges attract.
    • Like charges repel.
    • Charged objects attract neutral objects.

14. You should observe the presence of an attractive force at the end of the nail, but not at the end of the glass rod or wooden dowel.

15. The iron nail is a conductor. Metals are the usual conductors of electricity.

16. Glass and wood and other non-metals, such as plastics, are non-conductors. You may wonder how the plastic strip can hold a charge yet not be a conductor. This is because the charge is due to an accumulation of electrons on the surface. It is not a transmission of electrons through the material.

Section 1: Activity 2

1. Current electricity is the movement of charged particles from one point to another through a conductor.

2. In order to make electricity, you need the following two things:

    • a source of charged particles
    • a pathway or conductor to carry charged particles between points

3. You should never experiment with appliances and other electrical devices around the house.

14. The direction of deflection was reversed.

15. The amount of deflection increased as the number of turns of wire increased.

16. The needle did not deflect as far as it did in step 11.

17. The evidence that an electrical current produces a magnetic effect is the needle deflection in the compass. The needle is sensitive to magnetic effects.

18. The magnetic effect can be increased by increasing the number of turns of wire.

19. An ampere is a unit of measure. It measures the amount of current going through a given spot in a specific period of time. The symbol for ampere is A.

Section 1: Follow-up Activities

Extra Help

1. The plastic strip was charged and the paper roll was neutral, so they were attracted to each other. This attraction created a pulling force.

2. a. The two balloons repelled each other.

   b. The two balloons were given similar or like charges that pushed or repelled each other.

3. Static electricity can exert a force. This investigation showed both pushing and pulling forces which could be seen to either move objects or oppose another force, such as gravity.

Section 2: Activity 2

1. An electrical cell produces an electric current by converting chemical energy into electrical energy.

2. In the previous investigation you connected two lemons together. This is the same as connecting two _____cells_____ to make a _____battery_____.

3. If your radio takes four D-size 1.5 V cells, the total voltage of the batteries within the radio is _____6 V_____.

4. A voltmeter is used to measure the voltage of a battery.

Section 2: Activity 3

1. The two common features found in all cells are two different types of metal and a solution that surrounds the two metals.

2. Electrodes are the metal strips found in a cell.

3. An electrolyte is the solution in a cell.

4. Refer to the drawing on page 181 of your textbook.

   A chemical reaction within the cell occurs, causing a build-up of negative charges on the zinc electrode. At the same time, the carbon electrode loses negative charges. When the two terminals are connected with a wire, the negative charges move from the zinc electrode to the negative electrode, producing a current.

5. The main difference between a rechargeable cell and a zinc-carbon cell is that the chemical reaction in a rechargeable battery can be reversed. Electricity can be stored as chemical energy in a rechargeable battery. This requires a special electrolyte and special electrodes. Never try to recharge a non-rechargeable battery!

6. a. spacecraft: lightweight, small, sensitive, long lasting

   b. heart pacemaker: lightweight, small, long lasting, unaffected by microwaves so that it does not affect the timing of the pacemaker

   c. car powered only by batteries: quickly rechargeable, long lasting, large current output for a long period of time

Section 2: Activity 4

7. The problem can be stated as follows: How can you vary the brightness of your flashlight?

8. As the clips are moved further apart, the light bulb becomes dimmer. When the clips are moved closer together, the light bulbs become brighter.

9. You should notice that the nichrome wire is giving off heat.

10. The light bulb maintains the same brightness and there is no heat produced when a copper wire is used.

11. As electricity flowed through the nichrome wire, you could observe heat and light energy.

12. Textbook question 1. (a):

    The light bulb was brighter with two batteries hooked in series.

    Textbook question 1. (b):

    The further apart the clips were, the dimmer the light bulb became.

13. Copper wire allows more current to pass.

14. To increase the amount of current flowing through nichrome wire, you must shorten the length.

15. You would use copper wire, rather than nichrome wire, and two cells, rather than one, to provide more electricity.

16. A resistor is any device made of a certain material that will resist the flow of electricity through it.

17. All of the items listed use materials that have a high resistance to the flow of electricity. When electricity flows through the material, the electrons give up some of their energy to the material in the form of heat.

18. You will find a variable resistor or rheostat in any of the following items:

    - a dimmer switch which controls the brightness of a light bulb
    - volume controls on a radio or television
    - speed controls on electric motors

Section 2: Follow-up Activities

Extra Help

8. The further apart the clips are, the dimmer the light becomes.

9. The pencil lead has a high resistance to the flow of electricity. The longer the conducting length of the pencil, the higher the resistance. The greater resistance reduced the amount of electricity that flowed through the bulb.

10. The light would not change its brightness if copper wire was used instead of a graphite pencil.

Section 3: Activity 1

1. Most of the electricity used in houses is produced by generators.

2. Batteries convert chemical energy into electrical energy. Another way of making electricity is done by converting ___mechanical___ energy into ___electrical___ energy.

Section 3: Activity 2

3. You can make the light bulb brighter by speeding up the motion of the generator. To make the light bulb dimmer, you would slow down the generator.

4. As long as the generator is turning at the same speed, there will be no difference in the brightness of the bulb when the direction is reversed.

5. The two main components in the generator are the magnet and the coil of wire.

Section 3: Activity 3

1. The two types of magnets are the permanent magnet and the electromagnet.

2. The problem for this investigation may be stated as follows: How can you make and use a strong electromagnet?

3. The deflection will vary, depending on the strength of the battery and the gauge of the wire. You should be able to get anywhere from a 45° to 90° deflection.

4. The needle deflection is greater when you use the iron spike.

5. When you doubled the turns of the wire, the deflection of the compass needle became greater.

6. When another cell was added and you increased the windings, the magnet became stronger. There was a greater deflection of the needle.

7. You can increase the lifting strength of an electromagnet by doing any of the following things:

   - Increase the number of coils.
   - Use a large spike.
   - Add more cells.

8. An electromagnet has the following advantages over a permanent magnet:

   - varying the strength of the magnetic field
   - turning the magnet off and on when needed

Section 3: Follow-up Activities

Enrichment

1. People use solar power for calculators, heating buildings, for recharging batteries in remote areas, and in satellites.

8. Advantages of solar energy:

   - lightweight
   - no moving parts to wear out
   - pollution free

   Disadvantages of solar energy:

   - expensive to build
   - large number of cells to produce a small amount of electricity
   - can only be used under sunny weather conditions

9. Solar cells are practical in space because they are reliable. They have no moving parts, therefore, they do not wear out. Also, the sun always shines in space.

10. The proper name for converting sound waves into electrical energy is the piezoelectric effect.

11. Examples of devices that convert sound into electrical energy, or the reverse, electrical energy into sound, are microphones, record players, telephones, speakers, and radios.

Section 4: Activity 1

1. a. electric circuit: a pathway through which electricity can flow from the source and back to the source

   b. open circuit: a pathway that has a break in the circuit and the electricity cannot flow

   c. closed circuit: a pathway that does not have a break in the circuit and the electricity can flow

   d. switch: a device that can open and close a circuit

2. a. source: any device that converts one energy form into electrical energy (e.g., cell, battery, generator, plug)

   b. conductor: a material that allows the electricity to travel along a pathway (e.g., copper wire)

   c. control: a device which starts and stops the flow of electricity (e.g., switch)

   d. load: a device that changes electrical energy into another form of energy (e.g., light bulb, stove element, motor)

3. A series circuit is where the current follows one path through each load (device). A parallel circuit is where current can flow through two or more alternate paths.

7. The two main principles of a series circuit are as follows:

   - Each load is dependent on the other. If one fails, the others fail as well (e.g., If one light bulb is unscrewed, they all will go out.).

   - Each load reduces the amount of current going to the other loads (e.g., The brightness of the light bulbs dims each time that a new light bulb is added.).

10. Textbook question 3. (a):

    The battery would be drained faster with two lamps connected in parallel.

    Textbook question 3. (b):

    Each separate conductor takes an equal load. The two light bulbs in this configuration draw twice as much current from the source, as compared to a series circuit.

11. If one light goes out in a parallel circuit, the rest will remain on. In a series circuit, all the light bulbs will go out if one light goes out.

12. The two main principles of a parallel circuit are as follows:

    - There is more than one pathway for current to follow. Each load receives electricity independent of the other loads. If one fails, the others still work (e.g., If you unscrew one light bulb, the rest continue to work.).

    - Added loads (of the same voltage) do not increase the resistance of the circuit or reduce the current available for the other loads (e.g., The light bulbs' brightness stays the same. This will drain the cells much faster.).

13. Textbook question 5. (a):

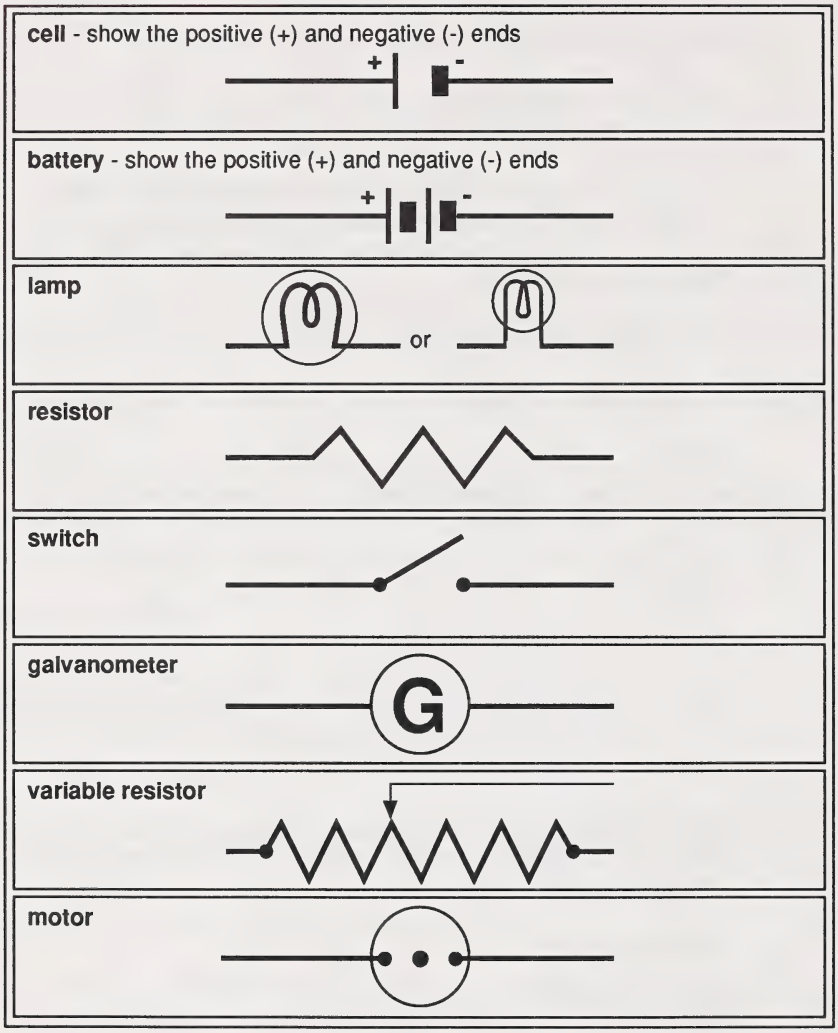
    The circuits in a house are wired in parallel.

    Textbook question 5. (b):

    If one light burns out, the rest of the lights stay on.

Section 4: Activity 4

1.



Section 4: Follow-up Activities

Extra Help

Note: The symbol for a light bulb is sometimes drawn as shown in the questions of Extra Help instead of as shown on page 205 of the textbook.

1. As you increase the number of cells, the light bulb becomes brighter.

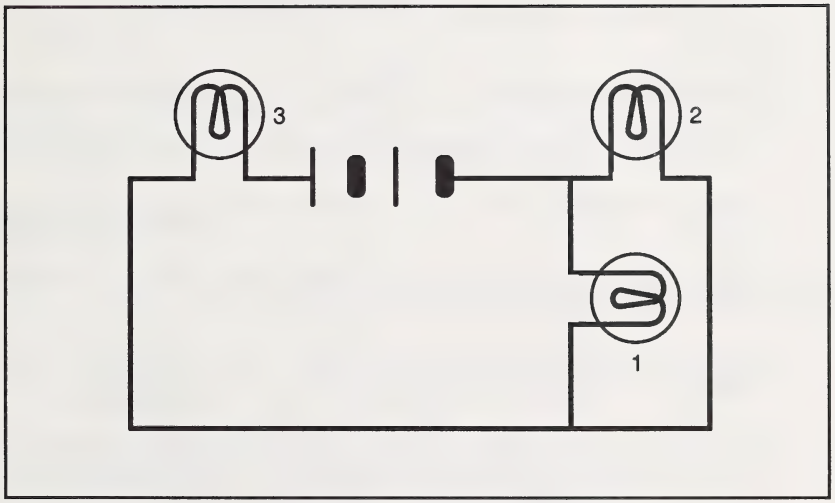
2. As you increase the amount of light bulbs, each bulb becomes dimmer.

3. The bulbs in the series circuit will be dimmer than the ones in the parallel circuit.

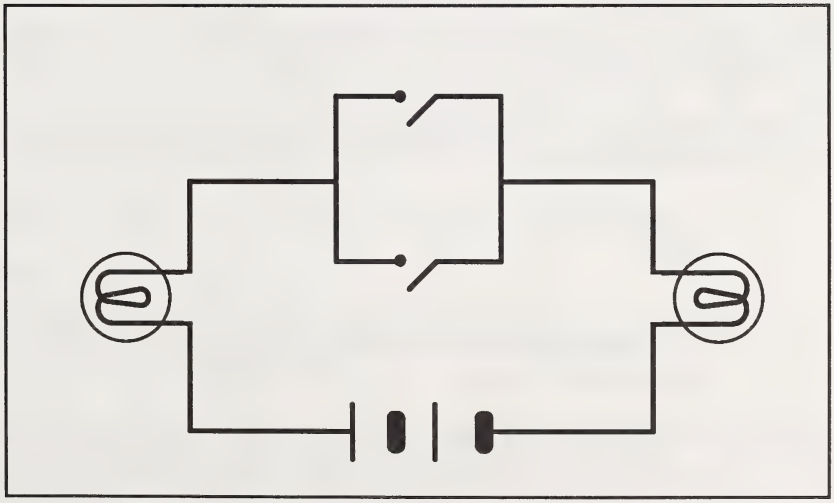
4. When a bulb is disconnected from the series circuit, the other light bulbs will not work. When a bulb is disconnected from the parallel circuit, the other light bulbs will still work.

Enrichment

1.



2.



Section 5: Activity 1

1. One of the three wires entering the house is grounded, or neutral. The other two wires, the live or "hot" wires, carry the electrical current.

2. When the wires first enter the house, they go through a meter. The purpose of this device is to keep track of the amount of electricity used.

3. Electricity next enters the master panel. This device has two functions which are to distribute the electricity and to hold the fuses or circuit breakers for safety.

4. Fuses and circuit breakers are used to limit the amount of electricity used by each circuit.

5. If too much electrical current passes through a fuse, a thin piece of metal melts, opening the circuit, and stopping current flow.

6. A circuit breaker has a bimetallic switch in it. If too much electrical current passes through the strip, it heats up, bends, trips the switch, and opens the circuit.

7. You should never replace a 20 A fuse with a 30 A fuse in a circuit designed for a current limit of 20 A. The purpose of a fuse is to prevent fire. Certain circuits can only handle so much electrical current. If you replace this circuit with a higher fuse, the fuse will not protect the circuit from overloading or shorting out.

8. Before replacing a blow fuse, find out why the fuse blew. If you do not know what the cause is, phone an electrician.

9. There could be a variety of answers for each picture. What follows are a few key points for each picture.

    a. top left: Water is a good conductor, therefore, no electrical device should be used near water.

    b. top right: One circuit cannot handle a large load. If you try to overload the circuit, it could overheat and start a fire unless the fuse blows or a circuit breaker trips. You should never overload a circuit.

    c. bottom left: Fraying wires expose the bare wires. A person can get a serious shock. Also, if two wires touch, this would cause a short, and possibly a fire. Replace frayed cords right away.

    d. bottom right: High-voltage lines are fatal if you touch them. Be careful when moving tall objects around them. Also, never fly kites near high-voltage lines.

10. There was no danger of electrocution because only a few 1.5 V batteries were used at any one time. The voltage involved was always low.

11. The voltage produced by sixteen cells in series is 24 V (16×1.5 V). Seventeen cells in series produce about 26 V. A voltage over 25 V is potentially dangerous. Therefore, the maximum number of D-size cells that can be safely connected in series is sixteen.

12. The bird does not provide a pathway for the electricity to get to the ground, so there is no current.

13. The bird would now provide a pathway to the ground through the tower and it would be electrocuted.

Section 5: Activity 2

1. There is a wide variety of devices that contain a bimetallic switch to measure temperature. Any of the following may be listed:

   - oven thermostat
   - furnace thermostat
   - refrigerator thermostat
   - car radiator thermostat
   - air conditioning thermostat

2. The hair dryer is comprised of two major subsystems controlled by a switch. When the switch is closed, electricity is supplied to these two subsystems. The first subsystem is the heating element. The element is made from thin wire that has a high resistance to the flow of electricity. This resistance changes electrical energy into heat energy. The second subsystem is the fan and motor. The fan's job is to push the hot air out the end of the dryer. The fan is turned by the motor. The motor converts electrical energy into mechanical energy.

Section 5: Activity 3

1. The two subsystems are the electromagnetic trap for the mouse and the bell to let you know when you have trapped the mouse.

2. You could add a third subsystem that uses a solar cell. As long as there is enough light, the solar cell will produce electricity. This electricity could be used to control the two subsystems. It could hold an electromagnetic switch open on the bell so that it will not ring. It could also be used to power the electromagnet to keep the tin can suspended. This will not be effected by the switch on the pie plate.

Section 5: Follow-up Activities

Extra Help

1. master panel
2. meter
3. ground
4. hot
5. fuse
6. breaker

U M X M L F Q F X K R
N L F X E O W X B C K
V G P Y N X D D B Q V
B P G Z A N K K S Z A
B Z B O P N V Y D V T
T C P D R Y E F O Z F
R G X B E I J B D I M
K E M C T D R E L W G
Q E T V S E N S F J S
I H B E A Q Q U T H Z
J M Z K M N J F O M C
J K E U O E G T V R Y
W R B P J E A A D M G

Measuring Electricity

If you are using a multimeter, the following operating instructions may apply. If you are using a different instrument, consult the operations manual for the instrument you are using.

Measuring Direct Current Voltage

Voltage is a measure of the "pressure" that causes electricity to flow. It is caused by the same forces that you saw acting between positive and negative static charges. However, with current electricity, the positive terminal draws electrons from a conductor. These electrons are eventually replaced by electrons supplied by the negative terminal. In order to measure the force present in a battery, you must attach a measuring instrument between the two terminals.

The multimeter shown below is used as a **voltmeter** to measure the voltage of the dry cell.

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The following procedure is to be used for measuring voltage if you are using the type of multimeter shown in the photograph. If you are using a different type of multimeter, follow the operating procedures outlined in the manual that accompanies the instrument you are using.

- Switch the dial to the appropriate setting on the direct current voltage scale. The numbers beside the symbol V give the highest voltage that will be measured accurately.

  Note: If you have no idea of the voltage that you are testing, always choose the highest scale (1000 V) first.

- Plug the red lead into the V (+) terminal and the black lead into the COM (–) terminal of the meter. (On multimeters having a single selector switch, this may already be done for you.)

- Connect the red probe to the positive terminal and the black probe to the negative terminal of the dry cell.
- Look at the reading in the screen. If a flashing (–) sign appears, turn the dial to a lower setting. If the numbers change too rapidly, change to the next highest setting.
- Read the voltage in volts or millivolts (1/1000 volt).
- Turn the dial to the OFF position and disconnect the metre from the circuit.

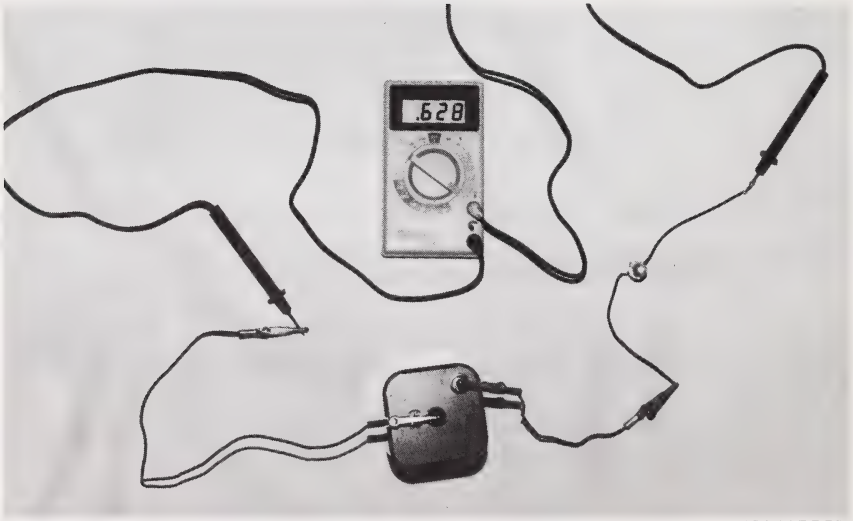
Measuring Direct Current Strength (Amperage)

A multimeter can be set to act as an ammeter, a device that measures the strength of an electric current.

When measuring current strength, a resistance such as a light bulb or small motor must be included in the circuit. The ammeter will measure the current used by this load.

Caution: Never connect a galvanometer, an ammeter, or a multimeter acting as a ammeter across the terminals of a battery. This will cause a short circuit and damage the instrument. A multimeter is protected by a 2 A fuse, but this is easily blown.

The multimeter shown below is used as an ammeter to measure the current used by a 1.5 V light bulb.



DAVE MORRIS

The following procedure is to be used for measuring amperage:

- Switch the dial to the appropriate setting on the direct current amperage scale. The numbers beside the symbol A give the highest amperage that will be measured accurately.

  Note: If you have no idea of the amperage that you are testing, always choose the highest (2 A) scale.

- Plug the red lead into the A (+) terminal and the black lead into the COM (–) terminal of the meter. (On multimeters having a single selector switch, this may already be done for you.)

- Connect the probes into the circuit. The red probe should be nearest the positive terminal. **Do not make the final connection to the battery until you have checked the other connections in the circuit and have the right scale-selection on the meter.**

- Look at the reading in the screen. If a flashing (–) sign appears, turn the dial to a lower setting. If the numbers change too rapidly, change to the next highest setting.

- Read the current strength in amperes, mA (1/1000 amperes), or μA (1/1 000 000 amperes). Ignore the negative sign if one appears.

- Turn the dial to the OFF position and disconnect the meter from the circuit.

Science 9

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